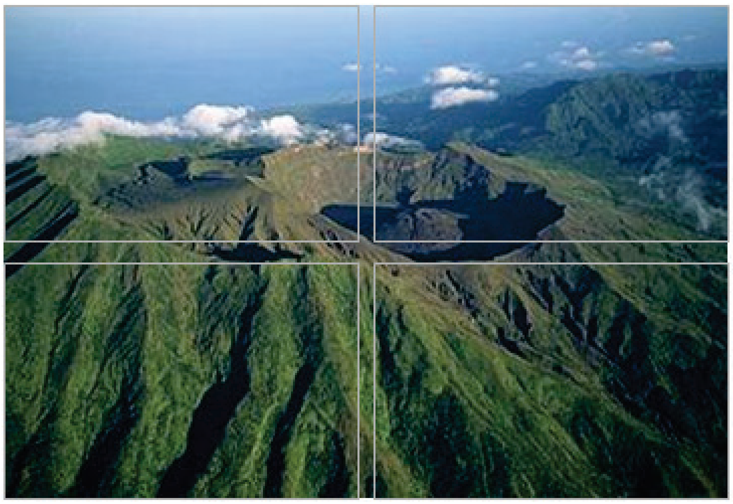
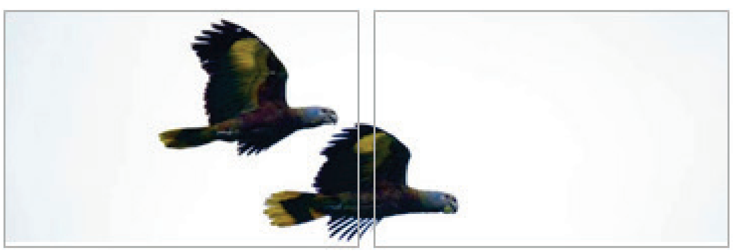




Prepared For:

St. Vincent Geothermal Project Phase I Exploratory Drilling Environmental and Social Impact Assessment (ESIA)

Draft Report

April 2016

Environmental Resources Management
1776 I (Eye) St NW
Suite 200
Washington DC 20006

www.erm.com

The world's leading sustainability consultancy.

ERM

Prepared for:

Government of St. Vincent and the Grenadines, Emera Caribbean, and Reykjavik Geothermal

Environmental and Social Impact Assessment of the St. Vincent Geothermal Project Phase I Exploratory Drilling
Draft Report

Date

David Blaha
Principal Partner

Environmental Resources Management
1776 I (Eye) St NW
Suite 200
Washington, DC 20002

http://www.erm.com

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS

^{o}C	degrees Celsius
AoI	Area of Influence
BOP	Blowout Preventer
CARICOM	Caribbean Community and Common Market
CHCMP	Community Health Construction Management Plan
CIA	Cumulative Impact Assessment
CO_2	carbon dioxide
CWSA	Central Water and Sewerage Authority
dB	decibel
dBA	A-weighted decibels
EC	Emera Caribbean Incorporated
EHS	Environmental, Health, and Safety
ESIA	Environmental and Social Impact Assessment
ESHS	Environmental, Social, and Health and Safety
ESMP	environmental and Social Management Plan
GDP	gross domestic product
GHG	greenhouse gas
GIIP	Good International Industry Practice
GWh	gigawatt hour
H_2S	hydrogen sulfide
HDPE	high-density polyethylene
IBA	Important Bird Area
IUCN	International Union for the Conservation of Nature
IDB	Inter-American Development Bank
IFC	International Finance Corporation
ISO	International Organization for Standardization
km	kilometer
km^2	square kilometer
L	liter
L/s	liters per second
Leq	equivalent sound pressure level
LPH	Light & Power Holdings
Mm^3	million of m^3
m	meters
m/m	meter per meter
m^3	cubic meter
m^3/h	cubic meters per hour
$m^3/h/m$	cubic meters per hour per meter
masl	meters above sea level
mg/L	milligram per liter
mm	millimeter
mph	miles per hour
MW	megawatt
N/A	not available

N_2	nitrogen gas
NGO	non-governmental organizations
NML	noise measurement location
NPRBA	National Parks, Rivers, and Beaches Authority
NRAS	National Register of Archaeological Sites
NRHB	National Register of Historic Buildings
NT	National Trust
OECS	Organization of Eastern Caribbean States
OHSAS	Occupational Health and Safety Advisory Services
PC	Project Contribution
PDC	polycrystalline diamond compact
PEC	Predicted Environmental Concentration
PPDB	Physical Planning and Development Board
PU	Physical Planning Unit
PPU	Physical Planning Unit
PS	Performance Standard
RAP	Resettlement Action Plan
RG	Reykjavik Geothermal
SEP	Stakeholder Engagement Plan
SGD	Saint George's Declaration
SO_2	sulphur dioxide
SPCC	Spill Prevention Control and Countermeasures
SV NT	SVG National Trust
SVG	Saint Vincent and the Grenadines
SVGCL	St. Vincent Geothermal Company Limited
TOR	Terms of Reference
the Project	St. Vincent Geothermal Project Phase I Exploration
US/U.S.	United States
VEC	Valued Environmental and Social Component
VINLEC	St. Vincent Electricity Services Limited

Page intentionally left blank.

EXECUTIVE SUMMARY

1.0 INTRODUCTION

he Government of St. Vincent and the Grenadines (SVG) and a consortium of Reykjavik Geothermal and Emera Caribbean Incorporated (collectively "St. Vincent Geothermal Company Limited" [SVGCL]) are proposing an approximately 15 megawatt (MW) geothermal power development in northern St. Vincent, on the southern slopes of the La Soufrière Volcano (see Figure ES-1). The Project would be the first of its kind in St. Vincent.

La Soufrière Volcano

The St. Vincent Geothermal Project will be developed in two phases:

- Phase I – Exploration, consists of the drilling and testing of one or two exploratory geothermal well pads, each with three wells, and associated project facilities (e.g., water system, road improvements); and
- Phase II – Production, consists of the development of a geothermal power plant and transmission lines to connect to the SVG power grid.

The objective of Phase I is to confirm La Soufrière Volcano geothermal reservoir characteristics and suitability for production thorough exploratory drilling. After confirmation, SVGCL will continue onto Phase II.

The St. Vincent Geothermal Project will be partially financed by the Caribbean Development Bank through the *Sustainable Energy Facility for the Eastern Caribbean Global Credit Loan* of the Inter-American Development Bank (IDB). As such, the Project must adhere to National guidelines (SVG *Draft Environmental Impact Assessment Regulations, 2009)* as well as the International Finance Corporation's (IFC) Performance Standards (PS) on Environmental and Social Sustainability (2012) and applicable IFC Environmental, Health, and Safety (EHS) Guidelines. ERM, an international sustainability consulting firm, was retained to prepare an Environmental and Social Impact Assessment (ESIA) of the St. Vincent Geothermal Project, covering only Phase I activities. A separate ESIA will be prepared for Phase II if the geothermal characteristics are determined suitable for power production.

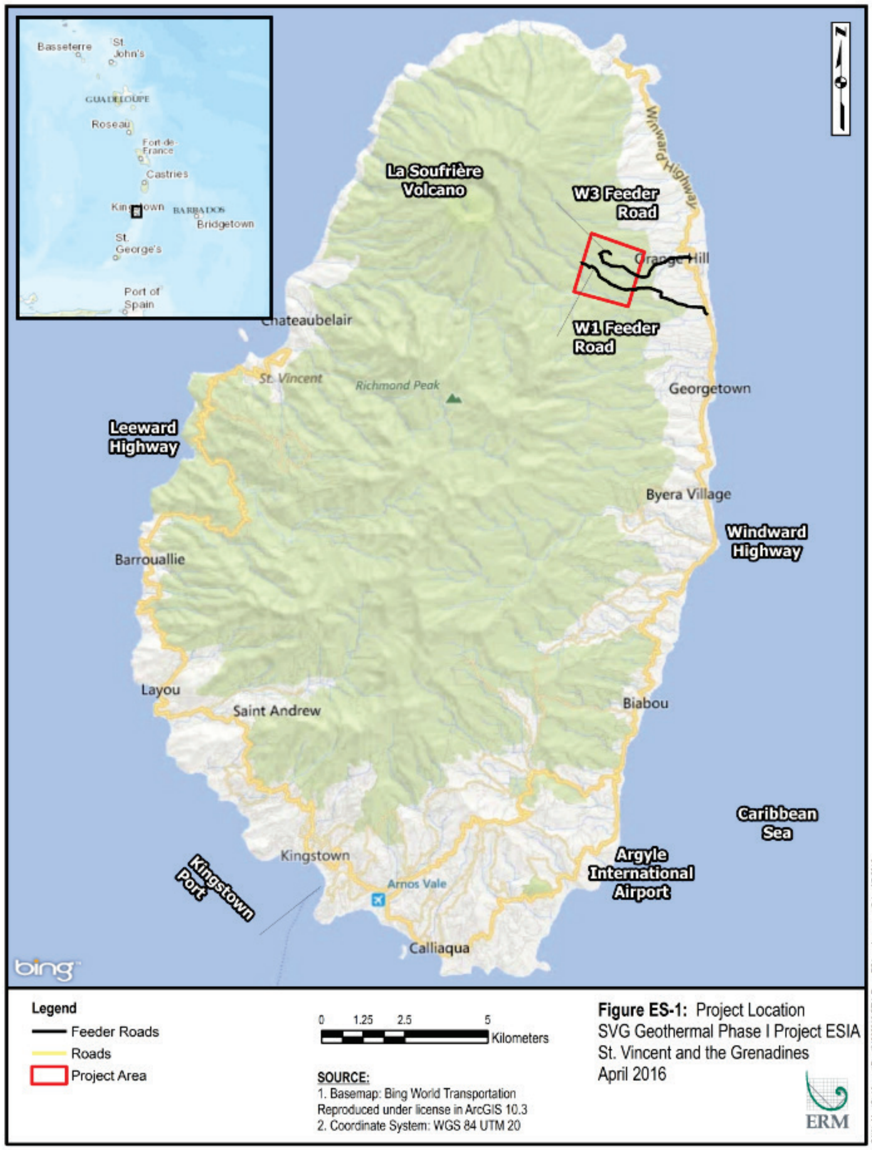


Figure ES-1: Project Location

2.0 PROJECT PURPOSE AND NEED

SVG is largely dependent on imported fossil fuels to meet its electricity demand, resulting in relatively high per capita greenhouse gas emissions and a large portion of the domestic gross domestic product spent on purchasing energy. Successful implementation of the St. Vincent Geothermal Development Project would increase the proportion of clean renewable energy in the national energy mix; lower and stabilize energy prices; reduce reliance on imported fossil fuels; reduce carbon emissions; increase energy independence; and promote economic development.

3.0 PROJECT DESCRIPTION

Phase I (the Project) activities involve drilling deep wells (between 1,000 to 3,000 meters [m] deep) in the Earth's crust to characterize the thermal heat resource contained in underground reservoirs of geothermal water or steam. The wells are drilled in clusters within drill pads or platforms. Exploratory drill wells bring to the surface a mixture of steam, gas, and water, known as brine. Drilling wells are allowed to let brine out (i.e., blow testing) to confirm the well production capacity. Injection wells return the brine and other geothermal fluids from the exploratory wells back underground.

SVGCL has requested approval for two exploratory drill pads, referred to as W1 and W3. SVGCL has indicated that they will construct the drill pads in sequence: first W1 and, if exploratory blow testing does not result in favorable results, then W3. If W1 blow testing results in favorable results, W3 will not be required. Figure ES-2 presents the location of the main Project components, which include the exploratory drill pads (W1 and W3), a water system (including a water intake, water supply pipeline, and a water storage pond), and injection well pads (one for each site).

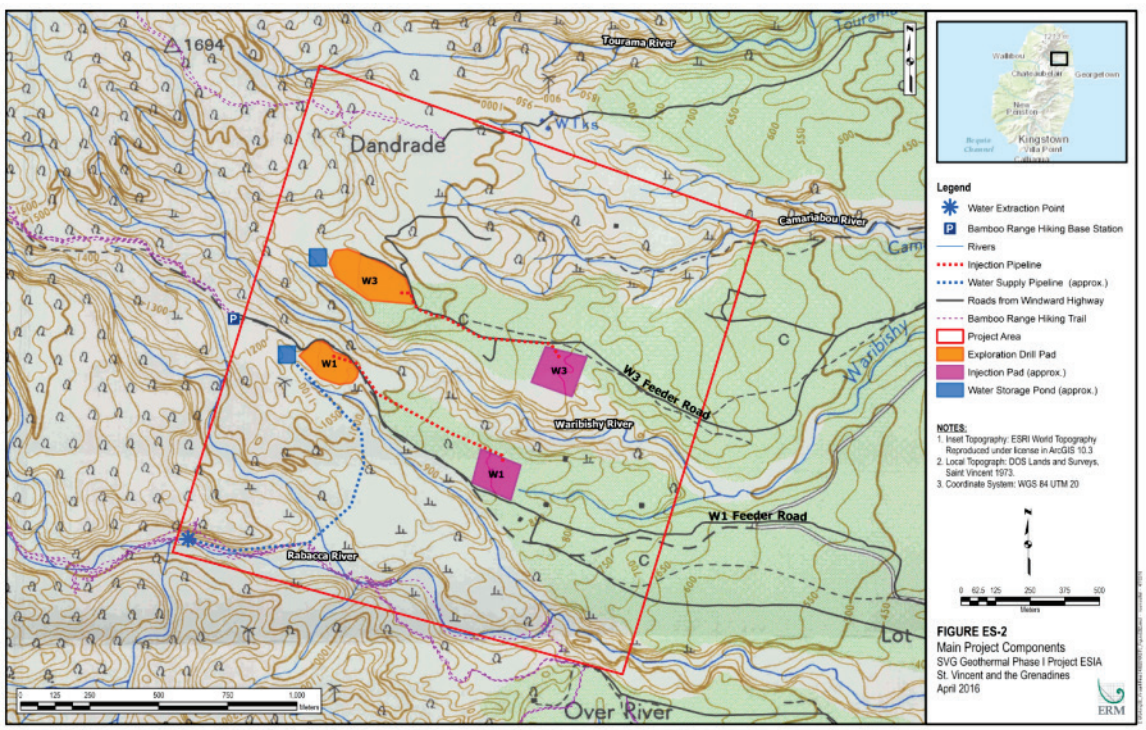


Figure ES-2: Main Project Components

The Phase I components and activities are described below:

- **Access Improvements and Transportation** - Project equipment and materials will be brought into Kingstown Port, which would not require any improvements, and then transported along the Windward Highway and secondary “feeder” roads near Langley Park and Orange Hill to the two exploratory drill pad sites (W1 and W3). No new road construction will be required, but improvements of the Windward Highway and feeder roads will involve cutting back embankments and widening curves within the right-of-way. Transport workers (e.g., drivers, flagman) will be hired locally.
- **Site Preparation** – Each exploration drill pad will occupy a surface of approximately 100 m by 100 m, including a drill mud pond. Other required facilities include a water system (i.e., a water withdrawal from the Rabacca River, a water pipeline to the drill site, and a water storage pond) and an Injection Pad. Site preparation will involve clearing and grading for these facilities. Excavated material will be reused or disposed offsite. Site preparation will require 10 to 15 workers, all locally hired.
- **Drilling** – Each drill pad will contain a drill rig; generator; drilling mud mixing/separation facility; drilling mud pond; and auxiliary facilities. Each exploration drill pad will have space for three boreholes, which could operate in the future as production wells if they yield the desired results. Drilling operations will continue 24 hours a day. Injection pads, which will be located approximately 500 m downhill of the drilling pad, will include one injection well that injects the extracted geothermal liquid back into the ground. Drilling will require up to 40 workers, with about 10 to 12 locally hired.
- **Exploratory Blow Testing** – Exploratory blow testing allows the exploratory wells to vent or blow in order to determine and evaluate the characteristics of the geothermal reservoir.
- **Decommissioning** – In case the testing results indicate that the exploration wells are not suitable for production, the Drilling Contractor would close and clean up the drill sites, remove the drill rig and other equipment, fill in the ponds, and revegetate the pad areas.

Table ES-1 presents a summary of the estimated timeline to conduct Project activities.

Table ES-1: Phase I Schedule by Activity

Activity	Estimated Time
Access improvement	2-3 months
Land transportation	Up to 5-7 days
Drill site preparation	Up to 4 months
Drill rig installation and drilling	55-60 days, per well
Exploratory blow testing	1-3 months, per pad
Decommissioning of drilling equipment	14 days

4.0 KEY PROJECT IMPACTS AND MITIGATION MEASURES

- **Stakeholder Engagement** – Knowledge of the Project varies among Project-Affected Communities; some are very familiar with the Project, but others appear to know little. The SVGCL has developed a robust Stakeholder Engagement Plan (SEP), which needs to be made publically available and, most importantly, implemented. ERM recommends that SVGCL hire a local Community Liaison Officer (CLO) to help keep the community informed about the Project and help address community concerns through implementation of the Project's Grievance Management. Implementation of these measures should adequately manage this potential risk.
- **Soil Erosion** – The Project could disturb steep slopes in a relatively wet climate, and therefore has the potential for significant soil erosion. ERM recommends that SVGCL develop and implements a Soil and Erosion Control Plan. Implementation of this plan should adequately manage this potential risk.
- **Noise** – Drilling and blow testing could generate noise levels of up to 120 A-weighted decibels (dBA). This intensity of noise, combined with 24-hour drilling, although temporary, results in exceedances of international nighttime noise standards (45 dBA) at distances of up to 500 m for drilling. As drilling noise can vary by drill rig, ERM recommends that SVGCL monitor noise levels immediately upon the initiation of drilling and implement a Corrective Action Plan (e.g., additional noise mitigation or physical resettlement) if noise levels exceed standards. SVGCL would provide Personal Protective Equipment for its employees and ear protection for nearby farmers if needed. Implementation of these measures, and at the worst case limited additional physical resettlement, should adequately manage these risks.
- **Water Resources** – SVGCL proposes to withdraw water from the Rabacca River to meet the Project's exploratory drilling water demands which primarily involves mixing water with bentonite (a clay) to serve as a lubricant. For the initial stages of drilling, there should be sufficient water in the Rabacca River to meet the Project's estimated water needs (0.2 liters per second [L/s]) and still leave sufficient water to support aquatic life in the river. During the final stage of drilling, however, the Project's water demand increases to 40 L/s for approximately 20 days. ERM recommends that SVGCL schedule their construction to avoid the final stage of drilling coinciding with the end of the dry season (January to March) to adequately manage these risks.

- **Aquatic Biodiversity** – The proposed water withdrawals from the Rabacca River could result in the loss of some aquatic habitat depending on the time of year. Migratory shrimps and the Sirajo goby fish rely on increased freshwater inputs from the river as a cue to begin migrating upstream. Proposed water withdrawals would decrease the volume of freshwater thereby reducing the strength of this migratory cue. These species also require a connected river system in order to reach upstream spawning habitat and for larvae to descend to the coast. Some of these species could be entrained at the Project water intake or be susceptible to unplanned hazardous material spills. ERM recommends that SVGCL try to avoid/minimize large water withdrawals during the end of the dry season, minimize the water intake velocity to the extent possible, and install wedge wire screens on the water intake to minimize entrainment, and implement spill control plans. These measures should adequately manage these risks to aquatic biodiversity.
- **Terrestrial Biodiversity** – The Project has a small footprint and would only directly impact a small area of modified habitat (e.g., banana plantation). The Project would also not directly impact any protected areas, but will temporarily degrade habitat quality as a result of noise, light, and increased human activity within the nearby La Soufrière National Park and Mount Pleasant Forest Reserve. As is common on small islands, the island of St. Vincent has 49 endemic or restricted range species, 29 of which occur or are expected to occur in the Project area, although the Project area is not known to support a concentration of any of these species. Two of the species are listed on the International Union for the Conservation of Nature Red List of Endangered Species: the St. Vincent Parrot (listed as Vulnerable) and the St. Vincent Whistling Frog (listed as Endangered). The Project is likely to impact individuals of these endemic/restricted range species to some extent as part of the required land disturbance and increased human activity (e.g., noise, light). ERM recommends that SVGCL conduct pre-clearing surveys immediately prior to construction to flush wildlife from areas to be disturbed and relocate sessile or limited mobility species to undisturbed sites to the extent practicable. ERM recommends that SVGCL avoid initiating construction during the St. Vincent Parrot (and other endemic bird species') breeding season (January to June) to avoid disturbing nesting birds, if operationally possible. Minimize noise from drilling and steam blow testing as described above. Implementation of these measures should adequately manage these risks.

St. Vincent Parrot

- **Waste Management** – The Project would generate drill muds, drill cuttings, domestic wastewater, and small quantities of other miscellaneous solid wastes. Neither the drill muds nor cuttings are hazardous, and would be stored in a lined mud pond, where the muds would be reused as a drilling lubricant and the cuttings (mostly rock) would settle to the bottom of the pond. After drilling is completed, the mud pond would be properly closed. The Project would also generate geothermal liquids, which are typically composed of high concentrations of various dissolved minerals. SVGCL proposes to collect and inject these liquids back underground. A latrine with a septic system would be provided to handle worker domestic wastewater. Miscellaneous solid waste would be disposed of in accordance with SVG regulations.
- **Land Acquisition and Economic Displacement** – The Project design has not advanced sufficiently at this time to fully assess the Project's land acquisition, physical resettlement, and economic displacement requirements. The draft Resettlement Action Plan (RAP) is robust, but needs finalization for the identification of people subject to physical or economic displacement. Based on ERM's field review of the general locations for the Project components, physical resettlement would likely be limited to a couple families. There are, however, small scale farmers who farm lands in the Project area that may be economically displaced. Once the Project design is finalized (at least for Pad W1), SVGCL will finalize a compensation program and continue to implement the RAP. No land acquisition should occur at Pad W1 unless in accordance with the RAP. Implementing the RAP and negotiating with the Project-Affected People regarding compensation in accordance with the IFC PSs should adequately address these issues.
- **Worker Code of Conduct and Grievance Mechanism** – The Project would require up to 40 workers, about 70 percent (approximately 28 workers) would be foreign labor. These workers would most likely be housed in nearby communities and would be working at the Project site for several months (more if drilling at Pad W3 is required). There is always the potential for conflict between foreign workers and local communities (e.g., prostitution, drugs, and spread of diseases such as HIV/AIDS). ERM recommends that SVGCL develop a Worker Code of Conduct to help manage these potential conflicts, with penalties (ultimately leading to termination of employment) for worker non-compliance. In addition, SVGCL should implement the Grievance Mechanism that provides a process to review and address any community complaints (e.g., worker conduct, noise, traffic). Implementation of these measures should adequately manage these risks.
- **Recreation and Tourism –** The preferred exploration drill pad, W1, is located along the feeder road to the Bamboo Range Hiking Base Station, where hikers ascend the La Soufrière Volcano, one of the most popular tourist attractions in SVG. The Project would affect these recreational

users by increasing noise levels and changing the visual landscape as they pass Pad W1. These impacts are considered minor as the noise and visual effects are quickly reduced to negligible levels as hikers leave the Base Station and ascend the volcano. In fact, a geothermal power development with appropriate information signage could function as a complementary attraction for tourists to the volcano.

- **Cultural Heritage** – The Project has the potential to affect the Byera Tunnel, the Orange Hill Aqueduct, and potentially other culturally important sites along the transport route to the pad sites. The SVGCL proposes to develop a Journey Management Plan that will help ensure measures are in place to protect these historic resources. There is also the potential that unanticipated discoveries may occur during construction, given the number of other archaeological sites known to occur in the Project area. ERM recommends that a Chance Finds Plan be adopted and implemented (see the Cultural Heritage Management Plan in Appendix E). Implementation of these plans should adequately manage these risks.

5.0 CONCLUSIONS

ERM concludes that the proposed St. Vincent Geothermal Project Phase I would result in environmental and social impacts, but these impacts could be readily mitigated and managed. The Project should comply with the requirements of the IFC PSs as long as the actions identified in the Environmental and Social Action Plan (ESAP) and the measures included in the Environmental and Social Management Plans (ESMP) (see Appendix E, Project ESMPs) are implemented.

Table ES-2: Project Environmental and Social Action Plans[1]

No.	Action Plan Item	Objectives/Comments	Responsible Party	Timetable for Action to be Completed
Prior to Construction at Pad W1				
1	Stakeholder Engagement	Complete, disclose, and implement a Stakeholder Engagement Plan (SEP) to ensure 1) consultation and disclosure of ESIA/ESMP documentation, and 2) ongoing community engagement during Construction, Drilling, and Testing.	SVGCL	Prior to Construction at Pad W1
2	Grievance Mechanism	Establish an understandable and transparent grievance mechanism that is culturally appropriate and readily accessible, and at no cost and without retribution for Project-Affected Communities, and people who would be physically or economically displaced by the Project.	SVGCL	Prior to CDB Board Approval
3	Government of St. Vincent and the Grenadines (SVG) approval.	Secure Government of SVG approval of the Project.	SVGCL	Prior to CDB Board Approval
4	Environmental and Social Management System (ESMS)	Prepare, for lender review and approval, an ESMS for the Project to ensure ongoing compliance with requisite environmental, health and safety and social standards (i.e., adopted environmental, social, health and safety standards (ESHS), Company commitments as outlined in ESIA) and to meet SVG legal requirements, IFC Performance Standards, and EHS Guidelines.	SVGCL	30 days prior to start of construction
5	Resettlement Action Plan (RAP)	Finalize Project land acquisition and economic displacement requirements, finalize RAP consistent with IFC Performance Standards, develop a compensation strategy, and implement the RAP.	SVGCL	Prior to land acquisition and construction
6	Soil Erosion and Sediment Control Plan	Prepare detailed Soil Erosion and Sediment Control Plan for all construction at Pad W1, including the water system, drill pad, and injection pad.	SVGCL	Prior to construction at Pad W1
7	Worker Code of Conduct	Prepare a Worker Code of Conduct to minimize conflicts with local communities.	SVGCL	Prior to construction at Pad W1
8.	St. Vincent Parrot Census	Conduct a St. Vincent Parrot population census in the forests surrounding the pad sites to establish a baseline to monitor the impacts of the Project on this species	SVGCL	Prior to construction at Pad W1
9	Journey Management Plan	Prepare Journey Management Plan to minimize traffic and safety issues associated with transported construction equipment and materials to Pad W1 for review and approval by the SVG .	SVGCL	Prior to the transport of equipment or materials to Pad W1
10	Community Liaison Officer (CLO)	Hire a CLO to help keep the community informed about the Project and to manage the Grievance Mechanism.	SVGCL	Prior to construction at Pad W1
During Project Construction, Drilling, and Testing at Pad W1				
11	Environmental and Social Management Plan (ESMP)	Implement the ESMP.	SVGCL	Throughout Phase I

No.	Action Plan Item	Objectives/Comments	Responsible Party	Timetable for Action to be Completed
12	Construction Timing	To the extent possible, avoid starting construction during the St. Vincent Parrot breeding season (from January to June) and avoid Stage 4 large water withdrawals from the Rabacca River during the low flow period (from January to March).	SVGCL	During construction at Pad W1
13	Noise and Air Monitoring	Install noise meters and H_2S monitors and confirm actual noise levels and H_2S concentrations comply with IFC Performance Standards and EHS Guidelines. If not, development an Action Plan to address this non-compliance.	SVGCL	Immediately upon commencement of well drilling. Provide monitoring report to lenders within 2 weeks.
14	Construction Monitoring and Reporting	Submit monitoring reports relating to compliance with applicable standards and monitoring requirements including air emissions, ambient air quality, noise and vibrations, effluent quality, groundwater quality, and solid wastes.	SVGCL	Quarterly reporting during Construction and Testing
Prior to Construction at Pad W3				
15	ESIA and RAP Addenda	Finalize design (e.g., land acquisition needs and provision of process water) and prepare addenda to the ESIA and RAP (if necessary) to identify and evaluate impacts associated with land acquisition and water supply. This ESIA Addendum should demonstrate Project conformance with the IFC Performance Standards and amend any SVG permits if necessary.	SVGCL	Prior to construction at Pad W3
16	Soil Erosion and Sediment Control Plan	Prepare Soil Erosion and Sediment Control Plan for all construction at Pad W3, including the water system, drill pad, and injection pad.	SVGCL	Prior to construction at Pad W3
Concurrent with Construction at Pad W3				
17	Site 1 Decommissioning	Decommission Pad W1 if it is determined to be unacceptable.	SVGCL	During drilling at Pad W3

CDB = Caribbean Development Bank; CLO = Community Liaison Officer; ESHS = Environmental, Social, and Health and Safety; ESIA = Environmental and Social Impact Assessment; ESMP = Environmental and Social Management Plan; ESMS = Environmental and Social Management System; H_2S = hydrogen sulfide; IFC = International Finance Corporation; PS = Performance Standard; SVGCL = St. Vincent Geothermal Company Limited

[1] An ESAP identifies and prioritizes actions needed to address gaps in the Project design, ESIA, management plans, management systems, or stakeholder engagement process to bring a Project in line with international standards.

1.0 INTRODUCTION

The Government of St. Vincent and the Grenadines (SVG) and a consortium of Reykjavik Geothermal (RG) and Emera (Caribbean) Incorporated (EC), formerly Light & Power Holdings, (collectively "St. Vincent Geothermal Company Limited [SVGCL]" or "Proponents") are assessing a possible geothermal development on the island of St. Vincent. The goal of the St. Vincent Geothermal Project is to provide approximately 15 megawatts (MW), and possibly, up to 20 MW, of clean electric power from a renewable source to SVG at a stable, cost competitive price compared to current means of power production in the country. The St. Vincent Geothermal Project would be the first of its nature in SVG.

The St. Vincent Geothermal Project would be developed in two phases. Phase I – Exploration (the Project), consists of the drilling and testing of two exploratory geothermal well pads and associated project facilities (e.g., water system, road improvements); Phase II – Production, consists of the development of a geothermal power plant and transmission lines to bring electricity to the SVG power grid. The objective of Phase I is to confirm La Soufrière Volcano geothermal reservoir characteristics and suitability for production thorough exploratory drilling. After confirmation, SVGCL would continue onto Phase II. Phase II – Production, consists of the development of a geothermal power plant and transmission lines to bring geo-thermally derived electricity to the SVG power grid.

The Project is located on the southern slopes of the La Soufrière Volcano on the island of St. Vincent (see Figure 1-1). Project activities will be carried out across the St. David and Charlotte parishes.

The Project will be partially financed by the Caribbean Development Bank through the *Sustainable Energy Facility for the Eastern Caribbean Global Credit Loan* of the Inter-American Development Bank (IDB).

The IDB retained ERM to conduct an Environmental and Social Impact Assessment (ESIA) for the Project in compliance with SVG regulations and the International Finance Corporation (IFC) Performance Standards (PSs).

Figure 1-1: Project Location

1.1 PROJECT PROPONENTS

A Letter of Intent was signed in January 2013 between the Government of SVG, RG, and EC to work together as a consortium on possible geothermal development in SVG. The consortium formed SVGCL under the laws of SVG to own and operate the St. Vincent Geothermal Project. The ownership structure for the proposed Phase I Company is illustrated in Figure 1-2.

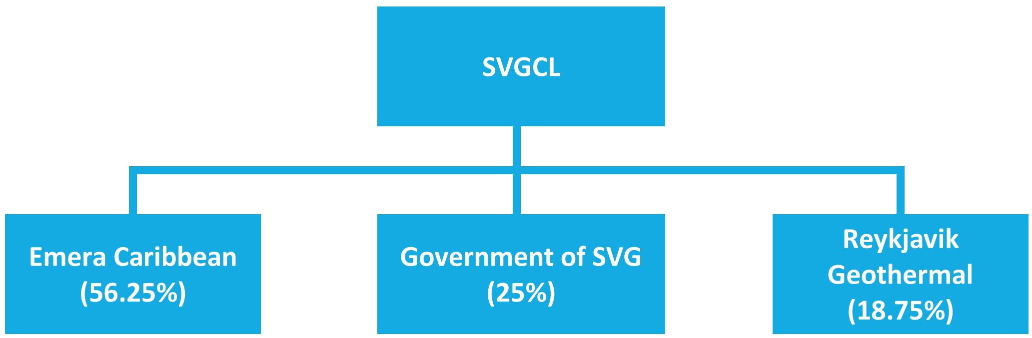


Figure 1-2: Ownership Structure of SVGCL

The individual Project proponents have agreed to negotiate the right of the Government of SVG to acquire a majority interest after 25 years of operation, as well as the right of first refusal upon any sale of the other proponents' equity interest in the Project. A brief description of each of the Project proponents is provided below.

Emera (Caribbean) Incorporated

In 2014, Light & Power Holdings was renamed "Emera (Caribbean) Incorporated" (or EC) to reflect its majority shareholder, Emera Inc., which holds approximately 80 percent of the shares in EC, with the remaining shares held by the National Insurance Board of Barbados (13 percent) and approximately 1,700 other shareholders (7 percent). Emera Inc. is an international energy and services company with roots in Nova Scotia, Canada. It has businesses in Canada, the United States (US), and the Caribbean. The company has approximately USD$12 billion in assets and 2015 revenues of USD$2.79 billion. The company has approximately 3,700 employees, and owns investments in electricity generation, transmission, and distribution; gas transmission; and utility energy services.

EC is based in Barbados and is traded on the Barbados Stock Exchange. EC invests in electricity generation, transmission, and distribution as well as gas transmission and utility energy services in the Caribbean. Its investments include the Barbados Light & Power Company Limited (wholly owned), Emera Caribbean Renewables Limited (wholly owned), Dominica Electricity Services

Limited (majority 52 percent interest), and St. Lucia Electricity Services Limited (19.1 percent interest).

Government of St. Vincent and the Grenadines

SVG is an archipelago of islands located in the Eastern Caribbean at the southern end of the Windward Islands chain. St. Vincent is the largest island, with the smaller Grenadines comprised by Bequia, Mustique, Canouan, Mayreau, Union Island, Palm Island, Petit St. Vincent, and a number of small islets. The country covers approximately 384 square kilometers (km^2) and has a total population of 109,360 (2014). The capital, Kingstown, has a population of approximately 25,000. The country gained independence from the United Kingdom on 27 October 1979, instituted a Parliamentary Democracy on the Westminster model, and has remained a part of the Commonwealth. Queen Elizabeth II is the head of state and is represented by the Governor General, Sir Frederick Ballantyne. The Prime Minister is Dr. Ralph Gonsalves. The legal system is based on English common law. The Ministry of Energy is the lead agency representing the Government of SVG's interests in the Project.

Reykjavik Geothermal

RG, based in Iceland, was founded in 2008 by a world leading geothermal management and science team. Prior to the formation of the company, members of the RG team were responsible for over a quarter of the world's geothermal power development over the previous 4 years. The RG management team has been involved with the development of over 3,000 MW of geothermal projects in over 30 countries, including all phases from greenfield development to the commissioning of the Hellisheidi power plant in Iceland, which is currently the world's largest combined heating and power geothermal plant. RG has a certified QHSE business management system consistent with International Organization for Standardization (ISO) 9001 (quality management), ISO 14001 (environmental management), and Occupational Health and Safety Advisory Services (OHSAS) 18001 (occupational health and safety). The company is also committed to the ISO 26000 standard on social responsibility and the SA 8000 standard on social accountability.

1.2 PURPOSE AND NEED FOR THE PROJECT

SVG is a country with a total population of approximately 110,000 (World Bank 2016). Like many island nations, SVG's energy matrix is largely dependent upon fossil fuels. In 2013, SVG obtained approximately 95 percent of its overall energy through imported oil products corresponding to 1,201 barrels of oil equivalent per day (IDB 2015a). Up to 17 percent of SVG's gross domestic product has historically been spent on oil derivate imports. The total cost of imported oil products has increased steadily over the past two decades in SVG (IDB 2015a).

More importantly, fluctuating petroleum prices added to fixed transport costs have significant influence over energy expenditures, with a liter of diesel currently selling for USD$0.88 (USD$3.36 per U.S. Gallon) (Nippon Koei *et al*. 2015; RG 2013).

The Government of SVG has prioritized the diversification of its energy supply, including a larger proportion of renewable sources. The *National Energy Policy* (2009) aims to: guarantee clean, reliable, and affordable energy supply to customers; strengthen the national economy by reducing dependence on imported fossil fuels; reduce dependence on the import of energy through exploitation of locally-available resources; liberalize the energy market by encouraging and accommodating private sector participation; and take advantage of renewable, local energy resources wherever possible. According to SVG's 2010 *Energy Action Plan*, renewable energy, comprised of local hydroelectric generation, accounted for 2 percent of the total power generation at that time. As a result, in addition to a relative lack of energy independence, per capita greenhouse gas emissions are relatively high.

St. Vincent Electricity Services Limited (VINLEC) is the sole provider of utility-scale electricity in SVG. Between 1998 and 2012, VINLEC's generation capacity increased at an annual rate of 5 percent. In 2012, VINLEC had a generation capacity of 53.7 MW, of which about 88 percent came from thermal generation and 11 percent from hydroelectric generation. On the island of St. Vincent, the installed capacity was 44.7 MW, provided mainly by two thermal plants (39.1 MW) and three hydropower plants (5.6 MW). However, the availability of hydropower decreases by up to 50 percent or more during the dry season. Electricity sales increased from 74.6 gigawatt hour (GWh) in 1998 to 128.6 GWh in 2012, representing an annual growth of 4 percent. VINLEC sales by sector correspond to 47 percent residential, 45 percent commercial, 5 percent industrial, and 3 percent street lighting (IDB 2015a).

Based on 2010 forecasts, deemed aggressive, the currently installed generating capacity of SVG is projected to meet demand until 2017 (IDB 2015a).

Because of the geothermal energy potential in and around La Soufrière Volcano in the northern area of St. Vincent, the SVG *Energy Action Plan* (2010) considers it possible for geothermal energy to supply a significant base load for SVG. The high enthalpy potential of SVG's geothermal resources will likely support expansion to supply increasing demand, and perhaps even export locally produced, low emissions energy.

Successful implementation of the St. Vincent Geothermal Development Project would increase the proportion of renewable energy in the national energy mix; lower and stabilize energy prices; reduce reliance on imported fossil fuels; reduce carbon emissions; and increase energy independence and sovereignty. The "no Project" alternative (see Section 3. 2, *Alternatives Analysis*) would perpetuate the SVG's current reliance on high cost imported fossil fuel sources for electricity production.

1.3 *OBJECTIVES AND SCOPE*

The objective of this ESIA is to assess the Project's environmental and social impacts in conjunction with the requirements of the IFC Performance Standards on Environmental and Social Sustainability (2012) and applicable IFC Environmental, Health, and Safety (EHS) Guidelines. This ESIA has been prepared following the SVG *Draft Impact Assessment Regulations* (2009).

Specific objectives of this ESIA include:

- Identification of positive and/or negative changes in the human and natural environment that may affect the quality of life as well as current and future options for sustainable social and economic development in the Project's Area of Influence (AoI);
- Identification of measures to minimize negative impacts and enhance positive impacts of the Project, following the mitigation hierarchy; and
- Analysis of alternatives and recommendations for the best course of action inclusive of any relevant prevention or mitigation measures.

As dictated by the SVG *Draft Impact Assessment Regulations* (2009) and internationally recognized good practice, this ESIA evaluates components of the Project during all activities (i.e., access improvements and transportation, drill site preparation, drill rig installation and drilling, exploratory blow testing, and decommissioning). Specifically, this study evaluated:

- Short-term effects, long-term impacts, and permanent impacts;
- Positive and negative effects;
- Direct and indirect effects;
- Predictable and unpredictable effects as a result of accidents and natural disasters; and
- Cumulative effects of the Project with other activities or development in the Project AoI.

All geographical information in this ESIA used projected coordinate system WGS 1984 UTM Zone 20N.

2.0 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

This chapter summarizes the relevant policy as well as the legal and administrative framework of St. Vincent and the Grenadines (SVG) applicable to the St. Vincent Geothermal Project Phase I Exploration (the Project) and the Environmental Impact Assessment (ESIA) process. The Project will be partially financed under the Sustainable Energy Facility for the Easter Caribbean Program; therefore, it requires alignment with international standards including the International Finance Corporation (IFC) Performance Standards (PS) and Environmental, Health, and Safety (EHS) Guidelines related to geothermal developments.

2.1 LEGAL AND ADMINISTRATIVE FRAMEWORK

2.1.1 National Legislation

The Government of SVG has the following two objectives:

- Protect, conserve, enhance, and restore natural resources and address environmental and social issues that may arise from developments; and
- Manage sectoral development issues.

Key environmental and social acts (laws) and regulations of SVG related to the Project include the following:

- Central Water and Sewerage Authority Act (No.17, 1991, 2007)
- Environmental Health Services Act (No.14, 1991)
- Environmental Impact Assessment Regulations (Draft, 2009)
- Environmental Management Act (Draft, 2009)
- Electricity Supply Act (No. 14, 1973) and the Electricity Supply (Agreement) Act (1984)
- Fisheries Act (1986)
- Forest Resource Conservation Act (No.47, 1992)
- Geothermal Resources Development Bill (2015)
- Land Acquisition Act (Chapter 241, 1947)
- Litter Act (1991)
- National Parks (Amendment) Act (No.13, 2010)
- National Parks Act (No.33, 2002) and accompanying Regulations
- Natural Resources Act (1947)
- Noise Control Act (No.18, 1988)
- Plant Protection Act (No.16, 2005) and Regulations (No. 9, 1991)
- Public Health Act (No.9, 1977)
- Standards Act (No. 70, 1992, amended 2001 and 2007)

- Town and Country Planning Act (No.45, 1992) and later amendments
- Waste Management Act (No.31 of 2000) and Solid Waste Regulations (No. 11 of 2005)
- Wildlife Conservation Act (1991)
- Wildlife Protection Act (No.16, 1987) & later amendments (1988 and 1991)

The *Town and Country Planning Act (1992)* and its amendments are the principal legislation governing land-use, spatial and physical planning, and the control of the development process. The Physical Planning Unit (PPU), governed by the Physical Planning and Development Board (PPDB), plays an integral role in implementing the Act. Under the Act (Article 29), an ESIA could be required for projects or activities that are likely to significantly affect the environment.

The *Draft Environmental Management Act (2009)* focuses on environmental issues and serves to compliment other legislation that exist in forestry, agriculture, and protected areas, among others. The objectives of this Act are to provide for the coordination of administrative responsibilities for environmental management within SVG, the prevention and mitigation of pollution in the environment (public health and maintaining the quality of environmental health), the conservation and development of renewable energy resources, and environmental management and monitoring.

The *Draft Environmental Impact Assessment Regulations (2009),* also known as the *Town and Country Planning Regulations* related to the 1992 *Town and Country Planning Act*, establishes the minimum ESIA requirements, the ESIA review process, and the stakeholder engagement framework. The PPU plays an integral role in following this Draft Act.

The *Geothermal Resources Development Bill* was drafted in 2012 by the Department of Sustainable Development of the General Secretariat of the Organization of American States through the Caribbean Sustainable Energy Program (CSEP)[i] and with support from the European Commission ACP-EU Energy Facility. The purpose of the Bill is to encourage and facilitate the safe production of geothermal energy for the benefit of the people of SVG, encourage responsible land management, and promote the use of renewable energy. This Bill supplements the 1973 Electricity Supply Act and specifies the conditions for geothermal resource development for permitting, license, and concession for geothermal resources development. In accordance to the approved 2015 Bill, geothermal projects are developed as follows (Geothermal Resources Development Bill [18 August 2015]):

[i] CSEP is a collection of government representatives from seven Caribbean States (including SVG) in efforts to reach the top of the Caribbean islands' national agendas and improve market conditions for the development and use of renewable energy and energy efficiency systems. Primarily since the island States have a particular vulnerability arising from their dependency on imported fuels and the concomitant local and global environmental damage caused by fuel generation (OAS 2016).

- Phase I - reconnaissance which is an activity having minimal impact on the environment of the land that determines, by visual observation of the geology and by geochemical studies, whether land may be a source of geothermal resources;
- Phase II – exploration which is an activity that demonstrated the dimensions, position, characteristics and extent of geothermal resources by geological, geochemical and geophysical studies and surveys including the drilling of shallow temperature gradient wells except that in the exploration stage temperature-gradient wells may not be drilled deeper than one hundred and fifty meters in depth without a safety certification as specified in the Regulations;
- Phase III - drilling which is an operation in which a well is drilled for the discovery of geothermal resources or for the production of geothermal resources or for the injection of geothermal resources or the residue and it includes drilling, re-drilling, and deepening of wells drilled for temperature-gradient monitoring purposes and for production purposes;
- Phase IV - geothermal resources production which is an activity that enables the supply of Class I geothermal resources to a power plant so that electricity can be produced from the geothermal resources; and
- Phase V - electricity production which is an operation in which electricity is generated from geothermal resources using power turbine generators.

Under the Bill, the Project is categorized as a Class I geothermal resource (i.e., capable of being used to generate electrical energy). As such, a permit, license, or concession is issued by the Minister of the Cabinet in each of the five Phases.

The *Land Acquisition Act (1947)* is also applicable as the Project would require the occupation of land, whether temporarily or permanently; some of the proposed land is used agriculturally and contains at least one home. This Act sets out the procedures and institutional responsibilities for acquiring land for public purposes and accompanying compensation arrangements.

The *Central Water and Sewage Authority Act* acknowledges that permission must be approved for a proposed project that will utilize a body of water.

The *Electricity Supply Act* states that the St. Vincent Electricity Services Limited may grant a sub-license to another person/body, which authorizes said person/body to also provide electricity for consumption.

Though some of the mentioned legislation is still in draft form (e.g., *Draft Environmental Management Act* and *Draft Environmental Impact Assessment Regulations*), the Government of SVG treats them as if they were in force.

2.1.2 *National Institutions*

Table 2-1 provides a summary of the main institutions and their functions and related legislation within the Government of SVG.

Table 2-1: Main Institutions of the Government of SVG

Institution	Relevant Legislation	Function
	Energy Department	
Minister of the Cabinet Office of the Prime Minister Energy Unit	• Geothermal Resources Development Act (2012) and Bill (2015)	Develop and implement energy policy, incorporating renewable energy and energy efficiency (e.g., geothermal energy in SVG).
	Ministry of Health, Wellness, and the Environment	
Central Water and Sewerage Authority	• Central Water and Sewerage Act (No. 6, 1978), amended in 1992 • Central Water and Sewerage Authority Act (No. 17, 1991; No. 38, 2007)	Conservation and maintenance of the environment in the interest of public health. Improved provision for the conservation, control, apportionment, and use of water resources.
Environmental Management Department Solid Waste Management Unit	• Environmental Health Services Act (No. 14, 1991) • Environmental Impact Assessment Regulations (Draft, 2009) • Environmental Management Act (Draft, 2009) • Waste Management Act and Regulations, Act (No.31 of 2000) and Solid Waste Regulations (No. 11 of 2005) • Public Health Act (No. 9, 1977) • Litter Act (No. 15, 1991)	Conservation and maintenance of the environment for health related to places frequented by the public. Responsible for the collection and disposal of solid waste on St. Vincent, and the development of waste facilities.
	Ministry of Agriculture, Forestry, Fisheries, and Rural Transformation	
Forestry Department Fisheries Department	• Natural Forest Resources Act (1947) • Forest Resource Conservation Act (No. 47, 1992) • Plant Protection Act (No. 16, 2005) • Fisheries Act (No.8, 1986), & later amendments (No.32, 1986, and No.25, 1989) • Wildlife Protection Act (No. 16, 1987) with amendments in 1988, 1991 • Wildlife Conservation Act (1991)	Promote and manage fisheries. Conservation, management, and proper use of the forest and watersheds; declaration of forest reserves, cooperative forest, and conservation areas. Conservation and sustainable management of the SVG forest, wildlife, and national park resources.

Institution	Relevant Legislation	Function
Ministry of Tourism, Sports, and Culture		
National Parks, River, and Beaches Authority	• SVG Tourism Authority (No. 39, 2007) • National Parks Act (No. 33, 2002) • National Parks (Amendment) Act (No.13, 2010)	Preserve, manage, protect, and develop natural and cultural heritage of SVG. Oversee and coordinate the management of the National Parks and Protected Areas, but with a focus on tourism and recreation activities.
Ministry of Housing, Informal Human Settlements, Physical Planning, Lands and Surveys, and Physical Planning		
Physical Planning Unit (PPU) Office of the Chief Surveyor	• Town and Country Planning Act (No. 45, 1992) • Town and Country Planning (Environmental Impact Assessment) Regulations (2009) • Land Acquisition Act (1947) • Noise Control Act (No. 18, 1988)	With a focus on Planning, management of development and how it interacts with the environment, including the evaluation and need for an ESIA. Land surveys for planning purposes and for land acquisition efforts.
Ministry of Transport, Works, Urban Development and Local Government		
Ministry	• Road Act (No. 15, 1955)	Oversight of all public infrastructure, including roads
Ministry of National Mobilization, Social Development, Family, Gender Affairs, Persons with Disabilities, and Youth		
Ministry		Management of Community Development-, poverty-, gender-, and youth-related programs.

Adapted from: Murray, Reynold 2014

ESIA = Environmental and Social Impact Assessment; SVG = St. Vincent and the Grenadines

2.2 *POLICY FRAMEWORK*

2.2.1 *National Policies*

The *National Economic and Social Development Plan 2013 – 2025* outlines the country's long- and mid-term strategies for national development as well as the quality of life for residents. The Plan focuses on the following:

- High and sustained levels of economic growth;
- High levels of human and social development; and
- Improved physical infrastructure and environmental sustainability, including building resilience to climate change.

This Plan provides a framework for the Government of SVG and private sector to work together using economic transformation for ongoing challenges to the people of SVG. This Plan seeks to improve upon the previous Plan that spanned from 1947 to 1995 by refocusing to achieve sustainable economic growth, job creation, and poverty reduction.

The *Government's National Energy Policy* (2009) provides the guiding principles for energy in SVG, which plays a major role in the diversification efforts of the economy and in the pursuit of poverty reduction. Its goals include:

- Efficient and well-coordinated planning and management activities to achieve sustainable supply and use of energy;
- Safe, efficient, reliable, affordable, and environmentally friendly electricity generation and supply for all parts of SVG with mention of geothermal energy;
- Increase the utilization of renewable energy technologies on all SVG islands; and
- Minimized energy input and lowest possible energy intensity for all energy related services.

A *National Physical Development Plan* is in preparation but has not yet been finalized.

2.2.2 *Regional Organizations*

SVG is a member of the Caribbean Community and Common Market (CARICOM)[ii] and the Organization of Eastern Caribbean States (OECS)[iii] organizations.

The goal of CARICOM Energy Policy is as follows:

> Fundamental transformation of the energy sectors of the Member States of the Community through the provision of secure and sustainable supplies of energy in a manner which minimizes energy waste in all sectors, to ensure that all CARICOM citizens have access to modern, clean and reliable energy supplies at affordable and stable prices. It is also to facilitate the growth of internationally competitive regional industries towards achieving sustainable development of the community. (CARICOM 2013)

[ii] The Treaty of Chaguaramas established CARICOM in 1973, and its purpose is to promote economic integration among its 15 Member States. Investors operating in SVG are given preferential access to the entire CARICOM market. The Treaty of Chaguaramas established the CARICOM Single Market and Economy (CSME) by permitting the free movement of goods, capital and labor within CARICOM States. This Treaty allows SVG to be the recipient of several benefits by being party to bilateral trade agreements with other member states (US Department of State 2014).

[iii] The Treaty of Basseterre established the Organization of Eastern Caribbean States (OECS), which is comprised of nine Member [island] States. The purpose of the Treaty is to promote harmonization among Member States in areas concerning foreign policy, defense and security, and economic affairs (US Department of State 2014).

In order to reach the goal of the CARICOM Energy Policy and to assure access to affordable and clean energy products necessary for the 15 Member States, CARICOM developed a program of regional actions with several objectives. Five of the 15 objectives related specifically to sustainable energy development are as follows:

- Sustainable and secure energy supplies developed through diversification of energy sources;
- Accelerated deployment of renewable and clean sources of energy supplies towards increased energy supply diversification and affordability;
- Increased investment in production, transformation, and distribution of viable energy sources;
- programmed expansion of electricity generation, transmission, distribution and trade; and
- Greater use of renewable energy for electricity generation as well as in the transportation, industrial and agricultural sectors.

The mission and objective of OECS is to be "a center of excellence to the sustainable development of Member States by supporting their strategic insertion into the global economy while maximizing the benefits accruing from their collective space" (OECS 2015). SVG is committed to the OECS Principles for Environmental Sustainability, as set out in the Saint George's Declaration (SGD) of 2001 and revised in 2006. The 21 principles contained in the SGD place environmental management as a key cornerstone of sustainable development, and OECS Member States have agreed to apply these principles in national policy-making and development decision-making. The SGD maintains the broad framework pursuant for environmental management within the OECS region and provides monitoring and reporting guidance for geothermal development.

2.2.3 *International Conventions and Agreements*

SVG is a signatory to various international conventions and agreements:

- Saint George's Declaration of Principles for Environmental Sustainability in the OECS;
- United Nations Convention on Biological Diversity;
- World Cultural and Natural Heritage;
- Kyoto Protocol;
- United Nations Framework Convention on Climate Change and the Paris Agreement;
- Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention) and the Land Based Sources Protocol; and
- Montreal Protocol Act.

These international conventions and agreements are referenced in this ESIA when applicable to the Project.

2.3 *NATIONAL ENVIRONMENTAL IMPACT ASSESSMENT PROCESS*

As mentioned in Section 2.1.1 above, Article 29 of the *Town and Country Planning Act (*1992) provides the legislative basis of the ESIA process. The PPU, which functions as the technical and advisory arm of the PPDB, has the legal authority for environmental management under this Act and is responsible for ensuring any development follows the national environmental and social requirements. As established by the *Draft Environmental Impact Assessment Regulations* (2009), ESIAs are required for projects or activities that are likely to significantly affect the environment.

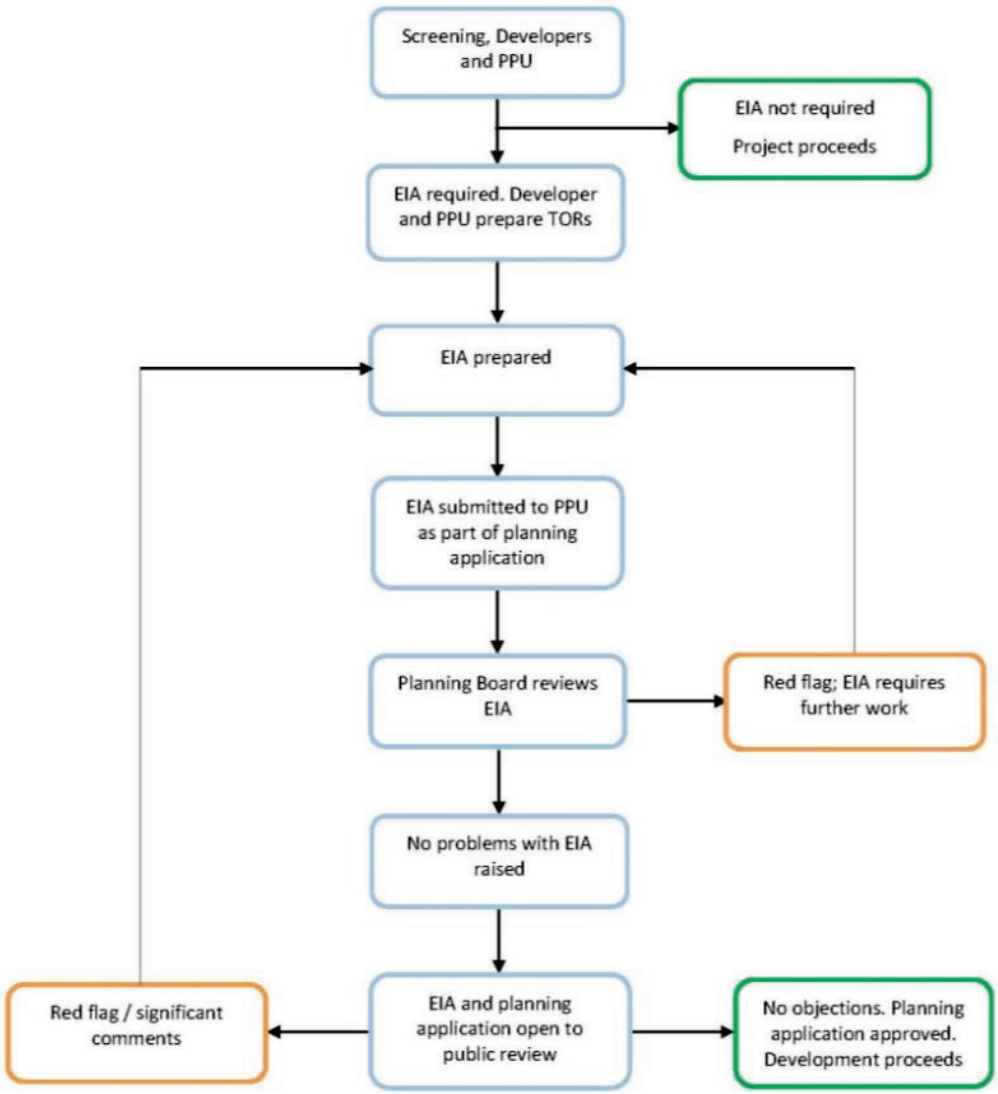
The PPU and PPDB collaborate to follow the *Draft Environmental Impact Assessment Regulations* (2009). Although not formally approved, this draft regulation is informally applied and all ESIA developments are requested to follow the established assessment and decision-making process. The ESIA process following the 2009 *Draft Environmental Impact Assessment Regulations* is shown in Figure 2-1.

The PPU determines the need and level of an ESIA and its review through a screening process. The *Draft Environmental Impact Assessment Regulations* (2009) establish three project categories: Schedule I (e.g., infrastructure, chemical industry, petroleum, cement, pharmaceuticals, large energy projects, metal industrial processing, mines, large hotels, and ports), Schedule II (not specified as type but as trigger by certain criteria), and Schedule III (e.g, land reclamation, fisheries, housing, large scale agriculture, deep drilling of water, hydroelectric power, paper and pulp, textile, food industry). Screening and categorization consider: social and economic considerations, environmental effects, public comments, and available mitigations. An ESIA is required for all Schedule I projects and may be required for Schedule II and III projects.

The terms of reference of an ESIA is confirmed through discussion between the project developer and the PPU. As a minimum, the ESIA should include the following:

- A description of the proposed activities;
- A description of the potentially affected environment, including specific information necessary to identify and assess the environmental effect of the proposed activities;
- A description of the practical alternatives;
- Assessment of the likely or potential environmental impacts of the proposed activities and the alternatives including the direct and indirect, cumulative, short-term and long-term effects;

- An identification and description of measures available to monitor or mitigate the adverse environmental impacts of proposed activities; and
- An indication of gaps in knowledge and uncertainty which may be factors in computing the required information.



Source: Nippon Koei *et al*. 2015

ESIA = Environmental Impact Assessment; PPU = Physical Planning Unit; TOR = Terms of Reference

Figure 2-1: ESIA Process in SVG

Consultation is an important element of the ESIA process. However, requirements for consultation and stakeholder engagement are not specified in detail and are discretionary in nature as presented in Article 15, of the *Draft Environmental Impact Assessment Regulations* (2009), which state:

- At any time during the ESIA process, the PPDB may invite written comments from interested persons concerning the environmental impact of the undertaking;

- The PPDB may forward the written comments to the developer, who shall answer any pertinent questions raised; and
- The procedure for public disclosure and involvement should be determined by the PPDB.

Following submission of an ESIA, it should be made available for public review. Generally, the PPU advertises that the draft ESIA is available at their offices for comment. The advertisement is published in three local newspapers and in a governmental gazette disseminated via governmental offices at the local level. A 14-day period is provided to the public for questions and concerns.

A National Environmental Appraisal Committee is appointed to review the ESIA, advise the PPDB of the adequacy of the ESIA, and determine if a public meeting is required. The Committee consists of nine members from various governmental departments: National Parks, Rivers, and Beaches Authority; Chief Environmental Health Officer; Town Planner; Chief Engineer of the Ministry of Works; Chief Economist; General Manager; Central Water and Sewage Authority; National Trust; and Forestry Department . If the Committee finds any deficiencies in the ESIA, they will recommend the PPDB to require the developer to provide further studies or information. If the Committee finds no deficiencies, they will recommend the PPDB to notify the developer to proceed with development.

As indicated by the *Draft Environmental Impact Assessment Regulations* (2009), The PPDB monitors the implementation of all conditions during the construction and operation phases of the project and conducts an inspection and review of the project after construction is complete. A developer submits regular reports to the PPDB prior to and during construction, and annual reports post construction.

2.4 INTERNATIONAL STANDARDS

2.4.1 IFC Performance Standards on Social and Environmental Sustainability

The IFC's PSs are widely utilized as a comprehensive set of guidelines and commitments directing sustainable and socially-responsible private sector development in emerging markets. They focus on avoiding adverse impacts to workers, communities, and the environment; when such impacts are unavoidable, they promote reducing, mitigating, or offsetting the impact.

PS 1: Assessment and Management of Environmental and Social Risks and Impacts

This PS highlights the importance of environmental and social management during a project. It covers a range of specific objectives aimed at minimizing environmental and social risks and impacts and the sustainable development of a project and its surroundings. PS 1 is designed to:

- Identify and evaluate environmental and social risks and impacts of a project.
- Adopt a mitigation hierarchy for risks and impacts to workers, Affected Communities, and the environment: to anticipate and avoid such risks and impacts; where avoidance is not possible, minimize such risks and impacts; and, where residual impacts remain, compensate/offset such risks and impacts.
- Promote improved environmental and social performance of clients through the effective use of management systems.
- Ensure that grievances from Affected Communities and external communications from other stakeholders are responded to and managed appropriately.
- Promote and provide means for adequate engagement with Affected Communities throughout the project cycle on issues that could potentially affect them and to ensure that relevant environmental and social information is disclosed and disseminated.

PS 2: Labor and Working Conditions

PS 2 acknowledges that the search for economic growth through employment creation and income generation must go hand in hand with the basic protection of workers' rights. This standard is based, in great part, on international conventions and instruments such as those established by the International Labor Organization and the United Nations. PS 2 is designed to:

- Promote the fair treatment, non-discrimination, and equal opportunity of workers.
- Establish, maintain, and improve the worker-management relationship.
- Promote compliance with national employment and labor laws.
- Protect workers, including vulnerable categories of workers such as children, migrant workers, workers engaged by third parties, and workers in the client's supply chain.
- Promote safe and healthy working conditions, and the health of workers.
- Avoid the use of forced labor.

PS 3: Resource Efficiency and Pollution Prevention

This standard aims to manage air, water and soil contamination and the excessive use of finite resources generally associated with an increase in economic and urbanization activities. PS 3 acknowledges that though development can be an important concomitant to improvement in quality of life, there is an offset where the same development may result in health risks and local community resilience as well as an increase in Greenhouse Gases (GHGs) and the loss of resources that contribute to ecosystem services. This PS is particularly relevant during the exploration and construction phase, as well as during operation. PS 3 aims to:

- Avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities.
- Promote a more sustainable use of resources, including energy and water.
- Reduce project-related GHG emissions.

PS 4: Community Health, Safety and Security

PS 4 is focused on managing health impacts that could result from project activities, infrastructure, and the use of equipment that is directly related to the project. This standard aims to anticipate and avoid adverse impacts to health and safety, including physical safety, increase in conflict, social change, and an increase in access to hazardous substances. It also seeks to safeguard the human rights of communities, particularly as it pertains to interactions with security personnel. PS 4 aims to:

- Anticipate and avoid adverse impacts on the health and safety of the Affected Community during the project life from both routine and non-routine circumstances.
- Ensure that the safeguarding of personnel and property is carried out in accordance with relevant human rights principles and in a manner that avoids or minimizes risks to the Affected Communities.

PS 5: Land Acquisition and Involuntary Resettlement

PS 5 is focused on the possible impacts associated with land acquisition and the restrictions of land use related to a project that may have adverse impacts on communities or people that customarily use those lands. This standard is germane only to transactions where individuals or groups lose access to lands they own, customarily use, or occupy. PS 5 is designed to:

- Avoid displacement; and when avoidance is not possible, minimize displacement by exploring alternative project designs.
- Avoid forced eviction.
- Anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use by (i) providing compensation for loss of assets at replacement cost and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected.
- Improve or restore the livelihoods and standards of living for displaced persons.
- Improve living conditions among physically displaced persons through the provision of adequate housing with security of tenure at resettlement sites.

PS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources

PS 6 recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and the sustainable management of living natural resources are fundamental for sustainable development. The objectives of this standard are focused on protecting and maintaining biodiversity and the benefits derived from the ecosystem, in addition to the sustainable management of living resources.

PS 7: Indigenous Peoples

PS 7 gives additional consideration to the added vulnerability that indigenous communities may experience because of their close relationship with the land and the natural resources, as well as the political, economic, social, and legal vulnerability, all of which decrease their resilience with regards to negative impacts and risks to their surroundings.

In accordance with the *Data Collection Survey for Geothermal Development In Saint Vincent and the Grenadines: Geothermal Development Project in SVG, Draft ESIA Scoping Report* (Nippon Koei *et al*. 2015), this PS is not applicable to the Project.

PS 8: Cultural Heritage

PS 8 recognizes the importance of cultural heritage to present and future generations. Its objectives are to protect cultural heritage from the adverse impacts of project activities and support its preservation and to promote the equitable sharing of benefits from the use of cultural heritage. This standard is applicable insofar as paleontological, archaeological, living, and architectural heritage may be impacted by the project's activities.

2.4.2 IFC EHS Guidelines

The IFC EHS Guidelines[iv] are technical reference documents that present general and specific examples of Good International Industry Practices. These criteria serve as EHS user's guides for specific sectors of industry. The EHS Guidelines contain performance levels and measures that are generally deemed reachable, applying existing technology at a reasonable cost. The ones most relevant to the Project are: *General EHS Guidelines* (2007)[v] and *Environmental, Health, and Safety Guidelines for Geothermal Power Generation* (2007)[vi].

[iv] http://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/ifc+sustainability/our+approach/risk+management/ehsguidelines

[v] http://www.ifc.org/wps/wcm/connect/554e8d80488658e4b76af76a6515bb18/Final%2B-%2BGeneral%2BEHS%2BGuidelines.pdf?MOD=AJPERES

[vi] http://www.ifc.org/wps/wcm/connect/329e1c80488557dabe1cfe6a6515bb18/Final%2B-%2BGeothermal%2BPower%2BGeneration.pdf?MOD=AJPERES&id=1323161975166

Page intentionally left blank.

3.0 *DESCRIPTION OF THE PROPOSED PROJECT*

As mentioned in Chapter 1.0, *Introduction*, St. Vincent Geothermal Company Limited (SVGCL) will carry out the St. Vincent Geothermal Project in two phases: Phase I - Exploration and Phase II - Production. The objective of Phase I is to confirm La Soufrière Volcano geothermal reservoir characteristics and suitability for production thorough exploratory drilling at two target sites. After confirmation, SVGCL would continue onto Phase II.

The St. Vincent Geothermal Project Phase I exploratory drilling (the Project) involves drilling deep wells (between 1,000 to 3,000 meters [m] deep) in the Earth's crust to characterize the thermal energy contained in underground reservoirs of geothermal water or steam. Wells are drilled in clusters within drill pads or platforms. Exploratory drill wells bring to the surface a mixture of steam, gas, and water, known as brine. Drilling wells are allowed to let brine out (i.e., blow testing) to confirm the well production capacity and the reservoir engineering of the geothermal system. Injection wells return the brine and other geothermal fluids from the exploratory wells back underground.

The Project components include the following:

- Two exploratory drill pads (W1 and W3), each with three deep exploratory drill wells;
- A water extraction, conveyance, and storage system for the water required during drilling;
- Two injection pads (W1 and W3), each with one injection well to inject the geothermal fluids obtained from the exploratory wells back underground;
- Improvement and upgrade of two feeder roads (W1 and W3) from the Windward Highway to the Project area; and
- Auxiliary components.

Figure 3-1 presents the location of the main Project components. The Project area is 4 km^2 (2 km by 2 km).

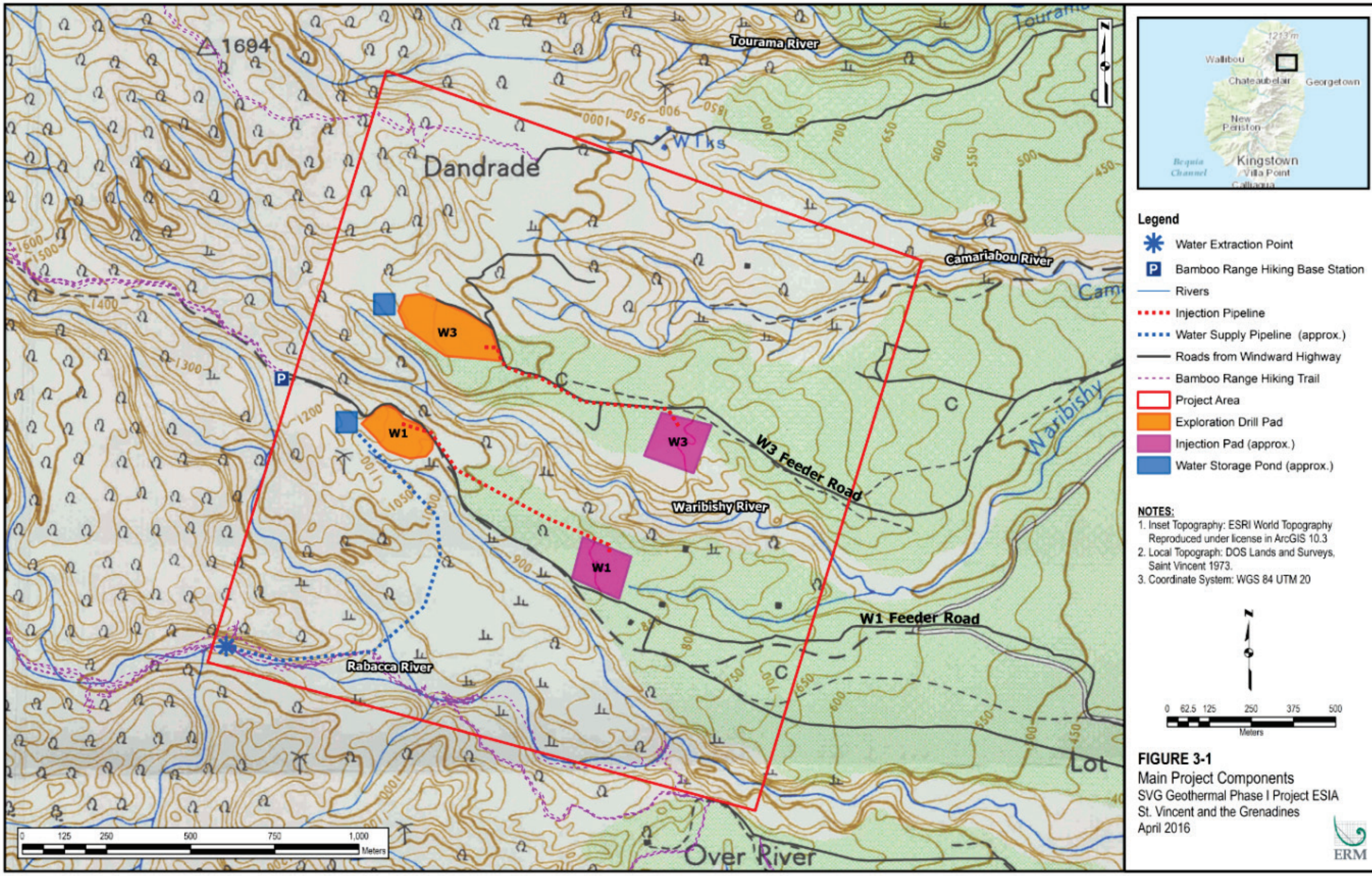


Figure 3-1: Main Project Components

This Chapter provides the Project background and planning activities carried out to-date, an analysis of alternatives, and a description of the proposed Project activities. The main sources of information include:

- *ESIA for Geothermal Exploration in St. Vincent Scoping Report* (RG and LPH 2013);
- *Feasibility Study to Assess Infrastructure Capacity for Geothermal Development at La Soufrière Volcano, St. Vincent* (Stantec 2015);
- *Draft ESIA Scoping Report for Geothermal Development Project in SVG* (Nippon Koei *et al.* 2015);
- *Request for Proposal for the Supply of Drilling Services Geothermal Development St. Vincent* (RG and EC 2016); and
- Supplemented information provided by SVGCL.

SVGCL is currently in the process of selecting a qualified Drilling Contractor who will be responsible for Phase I drilling services. Once selected, the Drilling Contractor will finalize the engineering specifics and details and will initiate W1 site (i.e., drill pad, injection pad, and feeder road).

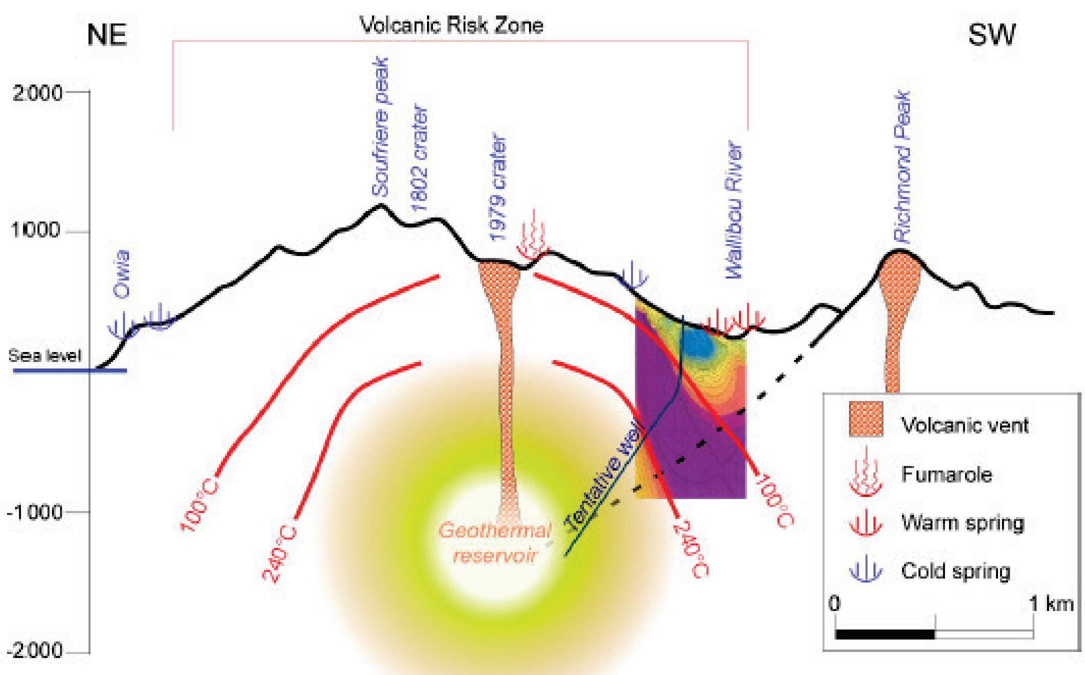
3.1 PROJECT BACKGROUND

SVGCL has conducted several studies and surveys to determine if the Project area has potential as a geothermal resource. At present, there are several technical studies prepared for the geothermal development:

- *A Geothermal Desk Study for Mt. Soufrière, St. Vincent* (Report No. 13002-01) prepared by Reykjavik Geothermal (RG) on April 2013;
- *Baseline Survey of the Environmental Impact Assessment of the Proposed La Soufrière Geothermal Filed North of St. Vincent* prepared by Dr. Reynold Murray on January 2014;
- *Resistivity Study of Mt. Soufrière, Saint Vincent and the Grenadines* (Report No. 13002-03) prepared by RG on February 2015;
- *Remote Sensing Report* (Report No. 13002:4) prepared by RG on February 2015;
- *Feasibility Study to Assess Infrastructure Capacity for Geothermal Development at La Soufrière Volcano, St. Vincent, W.I.* (Project No. 128013008) prepared by Stantec on March 2015;
- *Drilling Targets and Location of Drill Pads - Geoscientific Analyses* (Report No. 13002-05) prepared by RG on March 2015;
- *Nominal Well Design and Geological Prognosis for Well SVG-01, Mt. Soufrière, Saint Vincent and the Grenadines* (Report No. 13002-06) prepared by RG on September 2015;

- *Nominal Well Design and Geological Prognosis for Well SVG-02, Mt. Soufrière, Saint Vincent and the Grenadines* (Report No. 13002-07) prepared by RG on September 2015;
- *Data Collection Survey for Geothermal Development in Saint Vincent and the Grenadines. Geothermal Development Project in SVG. Draft ESIA Scoping Report*, by Nippon Koei, Geothermal Engineering Co, Ltd. and SRED on December 2015; and
- *St. Vincent Geothermal Drilling RFP* prepared by RG and EC on January 2016.

The initial studies included desktop geothermal studies, resistivity tests, and LiDAR topographic analysis. The studies confirmed that the La Soufrière Volcano area has the potential of becoming a geothermal source with the presence of a less than 230 degrees Celsius (ºC) geothermal reservoir (see Figure 3-2). Surveys indicated that the geothermal resource is closest to the surface at higher elevations and is more favorable on the eastern, windward side of La Soufrière Volcano. Analysis of the electricity demand on St. Vincent and the Grenadines (SVG) also indicates a sufficient electricity demand to make the St. Vincent Geothermal Project viable.



Source: RG 2013

ºC = degrees Celsius; km = kilometer; NE = northeast; SW = southwest

Figure 3-2: Conceptual Model of the St. Vincent Geothermal Reservoir

3.2 ALTERNATIVES ANALYSIS

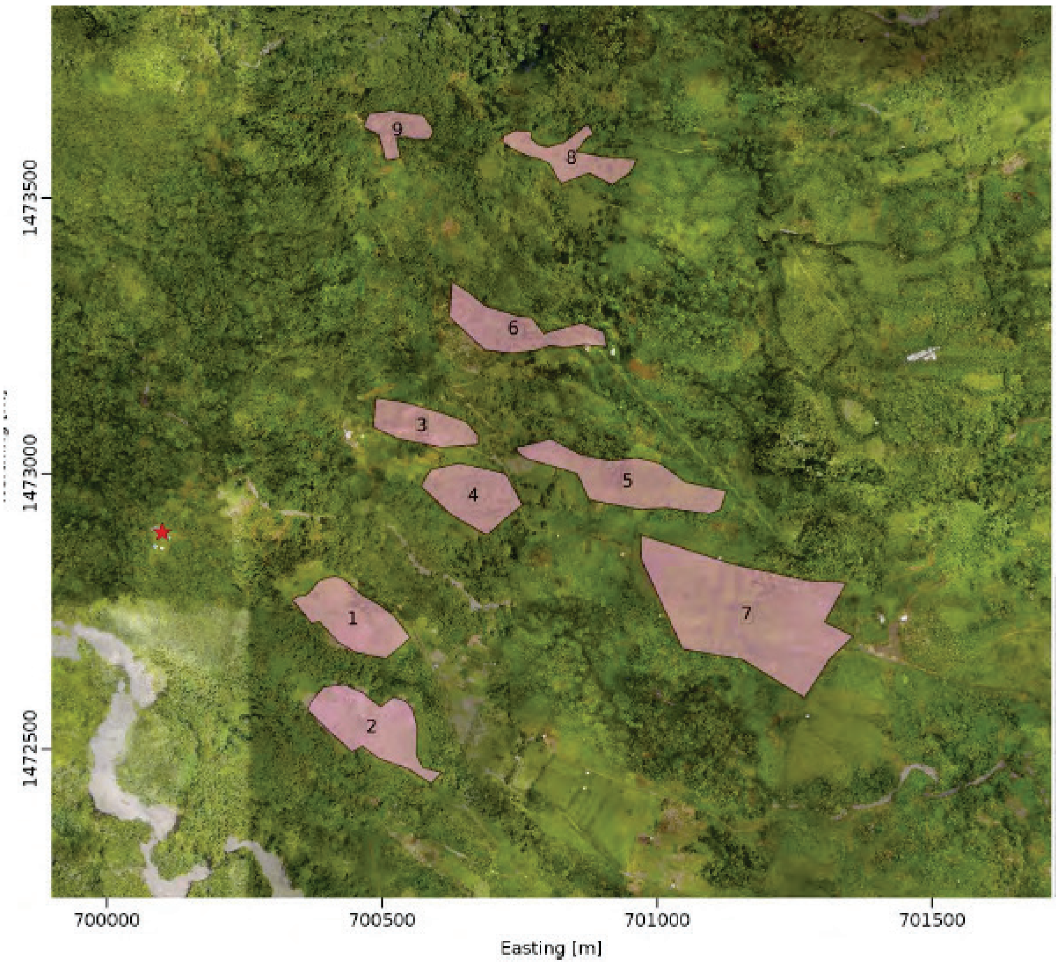
SVGCL evaluated various alternatives related to the development of the St. Vincent Geothermal Project as well as the location of exploratory drill sites, number of pads and wells, entry port, access route, and water sources for Phase I. Table 3-1 presents a summary of the alternatives analyzed.

Table 3-1: Project Alternatives Analysis

Aspect	Alternative	Analysis and Conclusion
St. Vincent Geothermal Project	• Project • No-Project	The St. Vincent Geothermal Project would result in lower and more stable energy prices, an increase in the proportion of renewable energy in the national energy mix, reduced reliance on imported fossil fuels, energy independence and sovereignty for SVG, and reduced GHG emissions. It can also result in energy expansion and possible economic development. It aligns with the SVG Energy Policy (2009) and Action Plan (2010). The No-Project alternative could perpetuate the current situation of a reliance on high-cost imported fossil fuel sources for electricity production while demand may rise. It could result in possible slower economic development, continued consumption of and probable increase in imported petroleum products, continued fluctuation of electricity price due to fluctuation of oil prices, and continued level of and probable increase in GHG emission.
Location of drill site	• Windward • Leeward	The windward site is located northwest of the Rabacca River, approximately 3.8 km west of the eastern coastline and 3.7 km east of the La Soufrière Volcano crater. The leeward site is located 3 km east of the western coastline and 4.5 km west of the La Soufrière Volcano crater. Based on the results of resistivity surveys and analysis of port and access road alternatives, the most suitable location is the windward location.
Port	• Kingstown Port • Camden Park Port • Beach and Dock Landing	The Kingstown Port is the main SVG port, located in Kingstown Bay. The port has an area of approximately 2.1 hectares, a wharf frontage of 280 m, and an available wharf area of 4,400 m^2. It receives cargo containers 6 m and 12 m long. It has security and several suitable points of access. The Camden Park Port is located 8 km north of Kingstown. It has a 68-ton-capacity dockside container crane and a mobile crane. It receives cargo containers 6 m and 12 m long. The access road is narrow, with steep grade, poor radius, and limited sight lines. Several beach landings were also evaluated: Calliaqua Beach and Brighton Beach on the windward side and Richmond Beach on the leeward side. The beach landing sites were found unsuitable due to wave conditions, water depths, distance to local fisheries, limited storage area, and/or access to roads. The Chateaubelair dock in the leeward side was also found unsuitable due to damaged infrastructure and access to roads. Based on characteristics, available temporary storage, and access, the most suitable port is the Kingstown Port.

Aspect	Alternative	Analysis and Conclusion
Access route	• Windward • Leeward	Phase I considers transportation of a large 20-25 m drill rig and various 12 m containers from the Kingstown Port to the drill site. The windward drill site is accessed by travelling 33 km along the Windward Highway, which was upgraded 6 years ago. The Feasibility Study found the road conditions, bridges, and culverts along the route suitable for transportation. The route crosses two points of interest: Byrea tunnel and Orange Hill aqueducts, both with adequate clearance for the containers and drill rig. Access to the windward drill sites is then through secondary paved roads, feeder roads, which will require upgrades such as curve widening. The leeward drill site location is accessed by travelling 40 km along the Leeward Highway. The Leeward Highway is a winding road with sections of very steep grades, poor vertical and horizontal alignments and 90-degree bends that could not support transportation of the containers and drill rig. The conditions of the highway vary from satisfactory to poor. Based on characteristics, the most suitable route is through the Windward Highway.
Number of exploratory drill pads	1 to 9	Results from the preliminary studies determined nine potential windward sites for drilling exploration wells (see Figure 3-3). The Feasibility Study recommended drilling sites W1 or W3 as part of Phase I. The selection of these two sites considered logistic settings like road access, land acquisition, and topographical conditions. According to the technical studies, there is no significant difference between W1 and W3; however, W1 has a slightly easier management of target penetration conditions than W3.
Water Sources	• Rabacca River • Tourama River • Waribishy River	The three closest surface waterbodies to drill pads W1 and W3 are the Rabacca, Tourama, and Waribishy rivers. Based on distance and hydrological conditions, SVGCL selected the Rabacca River for W1. SVGCL has not yet confirmed the water source for W3. From ERM field observations, the two rivers closest to W3, Waribishy and Camariabou, would not be adequate water sources as they dry up seasonally. The Rabacca River could be a potential water source for W3; pending feasibility assessment.
Energy	• VINLEC • Onsite power generators	The drill pads are located in a remote location on the slopes of the La Soufrière Volcano; therefore, connection to the VINLEC electrical distribution system is unfeasible. Energy will need to be provided by onsite power generators.

GHG = greenhouse gas; SVG = St. Vincent and the Grenadines; km = kilometer; m = meter



Source: Nippon Koei *et al.* 2015

Figure 3-3: Windward Drill Site Alternatives

3.3 *PHASE I ACTIVITIES*

The Phase I activities include:

- Access improvements and transportation;
- Drill site preparation;
- Drill rig installation and drilling;
- Exploratory blow testing; and
- Decommissioning.

The following sections present a description of the Phase I activities listed above. SVGCL will be responsible for the access improvement, drill site preparation, and decommissioning. Under the supervision of SVGCL, the Drilling Contractor will be responsible for equipment and material transportation, drill rig installation and drilling, and exploratory blow testing, as well as complying with all control and mitigations measures established in this ESIA.

3.3.1 Access Improvements and Transportation

The Project will use the Kingstown Port, located in Kingstown Bay on the western edge of the city of Kingstown. The Feasibility Study confirmed that the Port is suitable, with no improvements required. The Drilling Contractor will ship Project equipment and materials in approximately 70, 12 m long shipping containers in addition to the 20 to 25 m long drill rig. The Port management confirmed that the Port has the required temporary storage capacity.

SVGCL and Drilling Contractor can access the W1 and W3 drill sites from the Kingstown Port by travelling north 33 km along the Windward Highway. From the Windward Highway, access to the drill sites is through 12 m wide, secondary paved roads, known as feeder roads, near Langley Park and Orange Hill (see Figure 3-4).

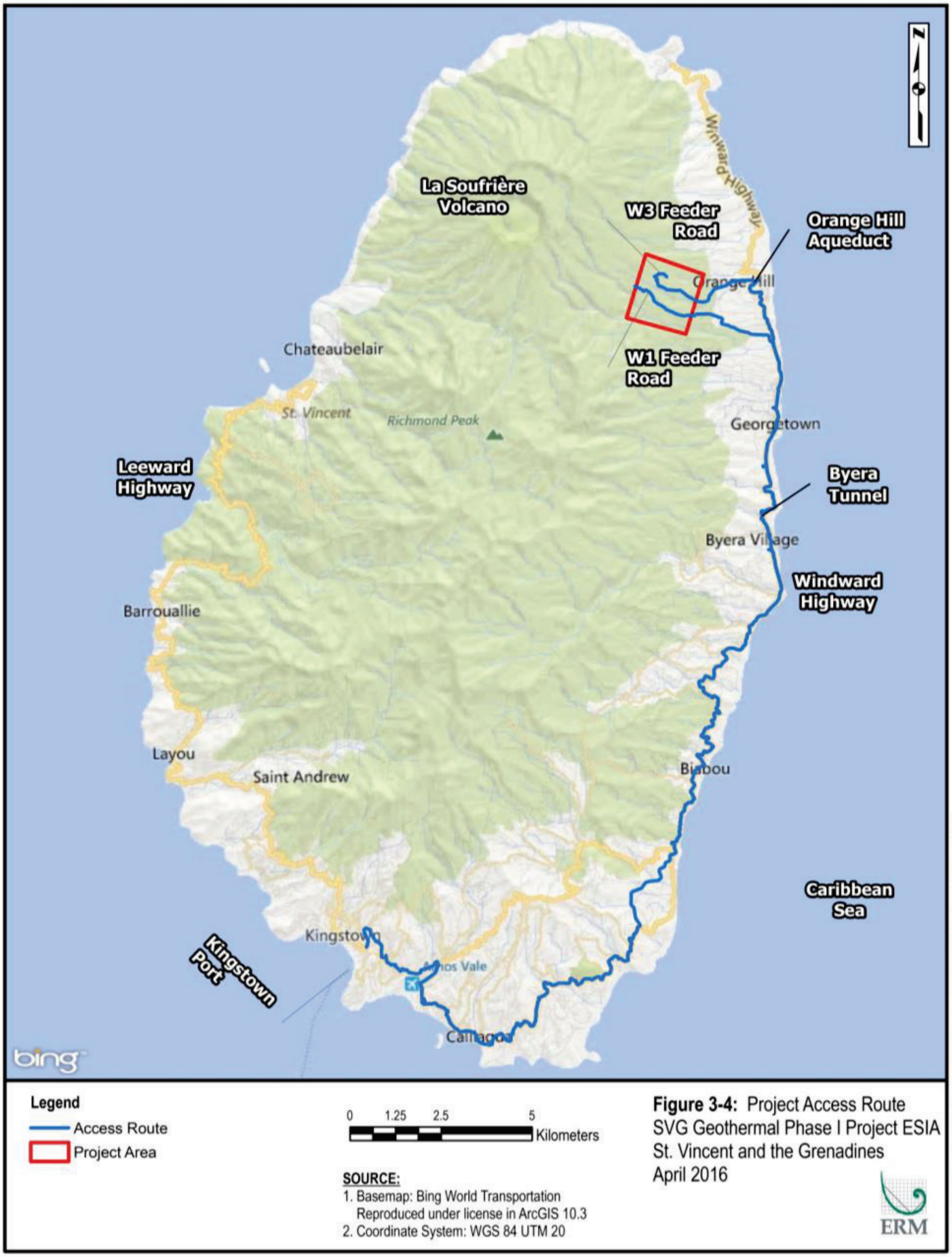


Figure 3-4: Project Access Route

The Windward Highway was upgraded approximately 6 years ago. The Feasibility Study found the road conditions, bridges, and culverts along the route suitable for Project transportation. Overhead powerlines, predominantly located near settlements, will require clearance prior to transportation. The route crosses two points of interest: Byrea Tunnel and Orange Hill aqueducts. The Byrea Tunnel, a 19th century historic structure, crosses a hillside near Byrea and is 60 m long with a 4.1 m wide road plus 1 m shoulders and a height of 5.8 m. The Orange Hill aqueduct is also a 19th century historic structure located in the Windward Highway south of Orange Hill settlement on route to the W3 feeder road. Both have adequate clearance for the containers and drill rig. The W1 feeder road, currently used to access the Bamboo Range Hiking Base Station, is in moderately good conditions along the 3.7 km from Windward Highway to the W1 site. The W3 feeder road from Orange Hill to the drill site is 3 km long.

Construction of new roads or roads segments will not be required. SVGCL identified that road improvements will be required for the Windward Highway between the Rabacca River and Orange Hill Settlement and for the two feeder roads. Improvement of the Windward Highway will involve cutting back embankments and curves. Improvement of the feeder roads will involve widening of curves and/or construction of drainage works, within the roads right of way. SVGCL will directly hire a local contractor or the Ministry of Transport, Works, Urban Development and Local Government to carry out the road improvements.

Once SVGCL finalizes road improvements, the Drilling Contractor will transport the equipment and materials from the Kingstown Port to the drill site in double axel container trailers pulled by articulate tractors. Transportation will take approximately 70 trips in up to 7 days. As a safety measure, the trailers will have escort vehicles and staff to warn other road users and pedestrians during transportation.

3.3.2 *Drill Site Preparation*

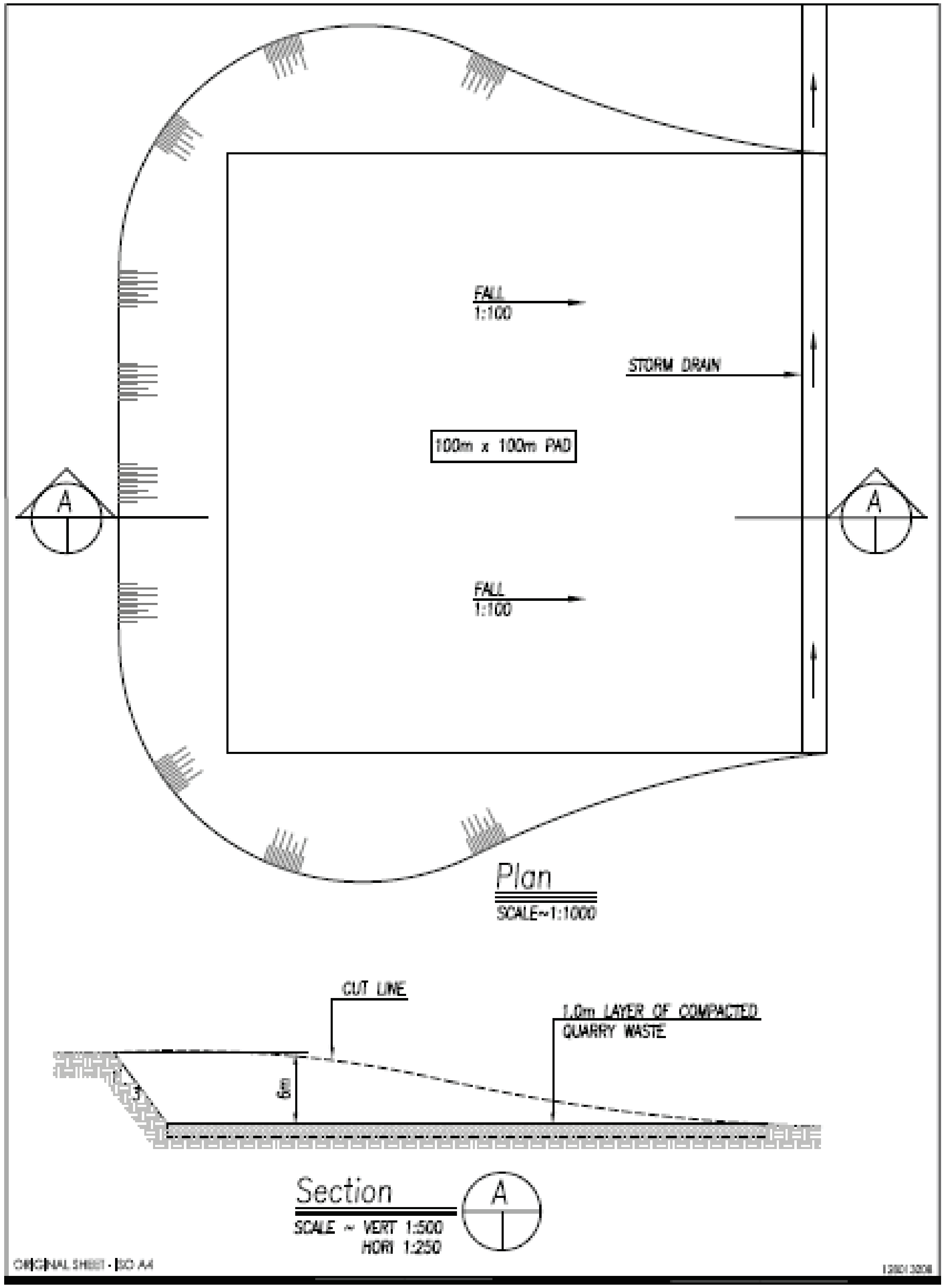
The Project site consists of the W1 and W3 exploration drill pads, each with an injection pad and a water storage pond (see Figure 3-1). SVGCL has indicated that they will construct the drill pads in sequence: first W1 and, if exploratory blow testing does not result in favorable results, then W3. If W1 blow testing results in favorable results, W3 will not be required. The impact assessment in Chapter 5.0 considers the construction, drilling, and testing of both W1 and W3.

Once SVGCL finalizes road improvements, they will clear the drill site area, cutting and grubbing existing vegetation such as crops, bushes, and trees and dismantling existing structures. During the site visit, ERM observed no structures on the pad locations (only nearby structures). However, SVGCL will need to confirm if existing structures are within the pad boundaries prior to preparation.

3.3.2.1 *Exploratory Drill Pad Preparation*

Each exploration drill pad will occupy a surface of approximately 100 m by 100 m, or 10,000 square meters (m^2; see Figure 3-5). The W1 and W3 sites currently present moderately steep terrain with slopes of 8 to 18 degrees. Using excavators, SVGCL will level the pad area, with a maximum cut depth of 6 m, and create stable 3H:1V (three-to-one ratio of horizontal to vertical) slopes around the uphill areas. The pad area will have a cross fall of at least 100H:1V to conduct surface runoff to a side storm drain (see Figure 3-5).

The W1 pad will produce 70,000 cubic meters (m^3) of excavated material, of which 30,000 m^3 will be reused for resloping and 40,000 m^3 will be disposed or reused offsite. The W3 pad will produce 55,000 m^3, with 30,000 m^3 reused onsite and 25,000 m^3 disposed or reused offsite. Earthwork activities will also include the excavation of a mud pond and a geothermal fluid pond within the drill pad area and a water storage pond and some rudimentary drainage structures outside the pad. Excess material will be reused (e.g., used as fill material for nearby areas or noise barriers) or disposed of according to national regulations and international best practice. A 1 m deep layer of compacted hardcore material underlain by a geotextile membrane will overlay the drilling pad area. The Drilling Contractor will place a fence around each pad once completed to prevent nearby community members or fauna from entering the future work area.



Source: Stantec 2015

Figure 3-5: Preliminary Design of Drill Pad

3.3.2.2 *Injection Pad Preparation*

The injection pads will be located approximately 500 m downhill from the exploration drill pads, and will have similar dimensions and characteristics as the drill pads. The Drilling Contractor will confirm the precise location and dimensions of the injection pads; this ESIA uses approximate location and dimensions. Construction of the injection pads will require the same type of material and equipment used for the exploration drill pads. The Drilling Contractor will place a fence around each pad once complete to prevent nearby community members or fauna from entering the future work areas.

SVGCL and the Drilling Contractor will use the injection pads as laydown areas during construction of the exploration drill pad and installation of the drill rig.

3.3.2.3 *Water Supply System*

SVGCL has estimated that the drilling operations may require up to 50 liters/second (L/s) or 180 m^3/hour of water. Drilling requires water for the make-up of drilling fluid, consisting of water mixed with bentonite clay. Drill fluids facilitate the transportation of cuttings to the surface, cool and lubricate the drill string during drilling, remove cuttings from muds at the surface, control formation pressure, and maintain borehole integrity.

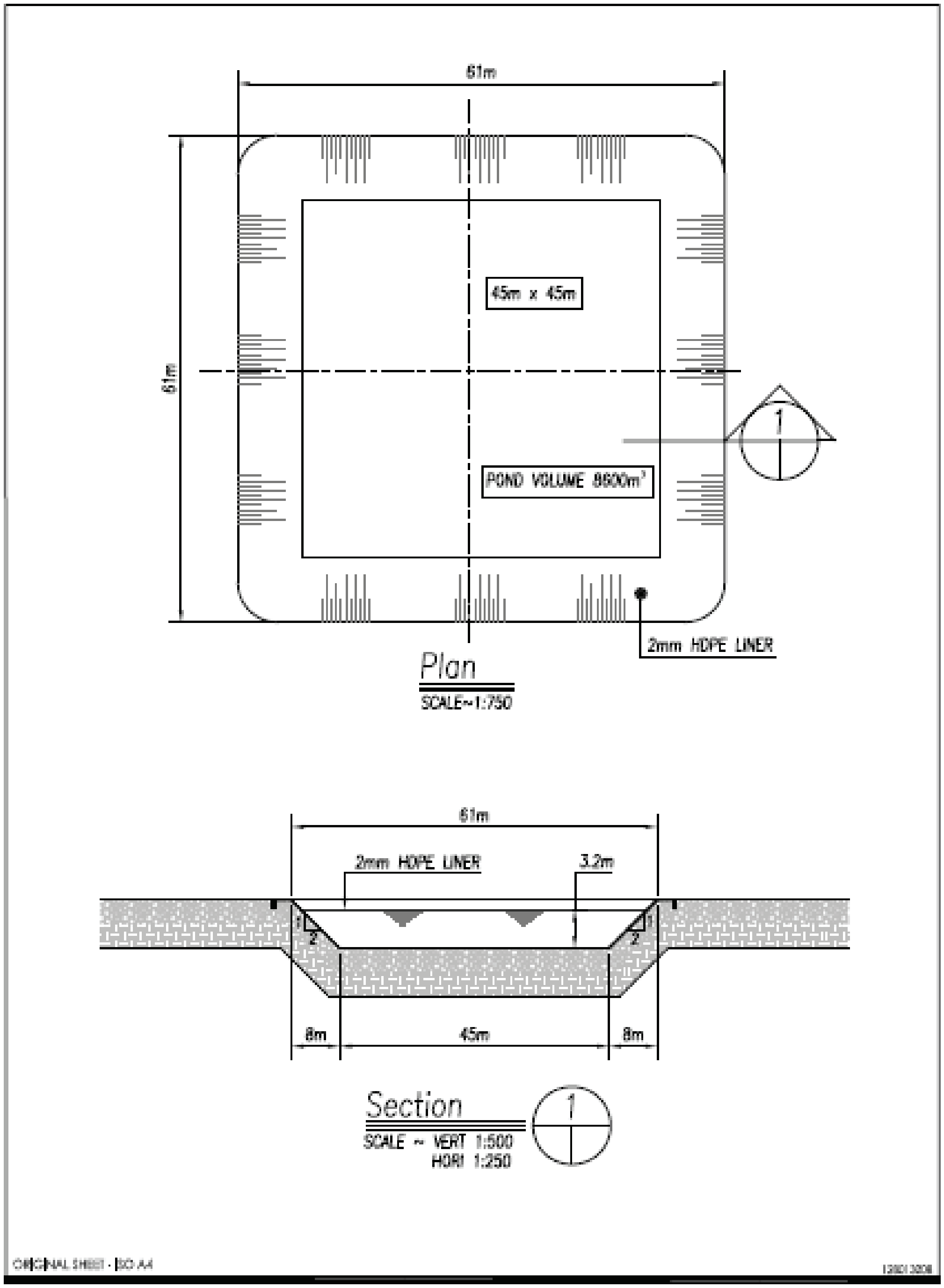
SVGCL proposes water withdrawal from the Rabacca River to meet this demand. Preliminary studies identified a water extraction location for W1 (see Figure 3-1). SVGCL has not yet confirmed the water source and extraction location for W3. From ERM field observations, the two rivers closest to W3, Waribishy and Camariabou, would not be adequate water sources as they seasonally dry up. The Rabacca River could be a potential water source for W3; pending feasibility assessment.

The water supply system will involve the following components, shown in Figure 3-1:

- Create a water extraction point – SVGCL will create a small pool within the Rabacca River (699,956 E - 1,472,060 N WGS 84 UTM Zone 20) to ensure adequate depths to withdraw water.
- Pump – SVGCL will install a diesel or electrical driven water pump that would withdraw the required water from the Rabacca River.
- Water supply pipeline – SVGCL will construct an approximately 1.3 km long, 25 cm high-density polyethylene (HDPE) or steel pipeline to convey water from Rabacca River to a water storage pond located upslope of the W1 drill pad.
- Water storage pond – SVGCL will construct a water storage pond located uphill from the W1 drill pad site to provide water by gravity with a 48-hour storage capacity to ensure a continuous water supply during

drilling. The water supply pond will have a storage capacity of 8,640 m^3, excavated with side slopes of 2H:1V, with a top plan dimension of 61 m by 61 m and a bottom plan dimension of 45 m by 45 m. The liquid depth will be 3.2 m. SVGCL will line the ponds with a 2-millimeter (mm) thick HDPE membrane to prevent seepage (see Figure 3-6).

- Water pipeline – SVGCL will construct an approximately 30 m pipeline connecting the water storage pond to the drill pad.



Source: Stantec 2015

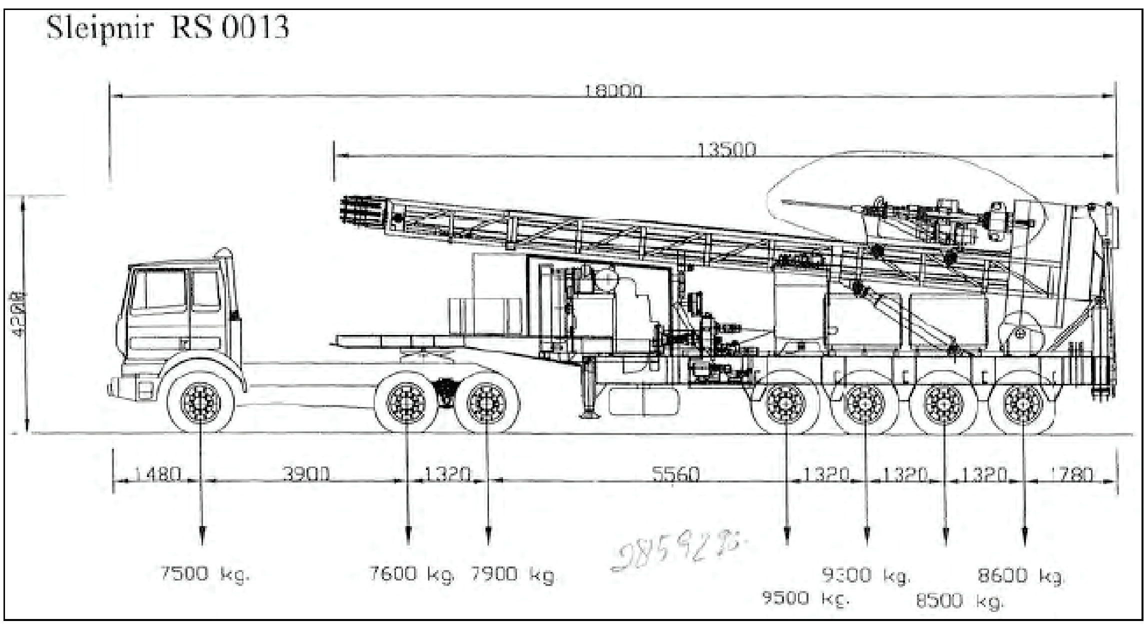
Figure 3-6: Preliminary Design of Water Supply Pond

3.3.3 *Drill Rig Installation and Drilling*

Each drill pad will contain the following:

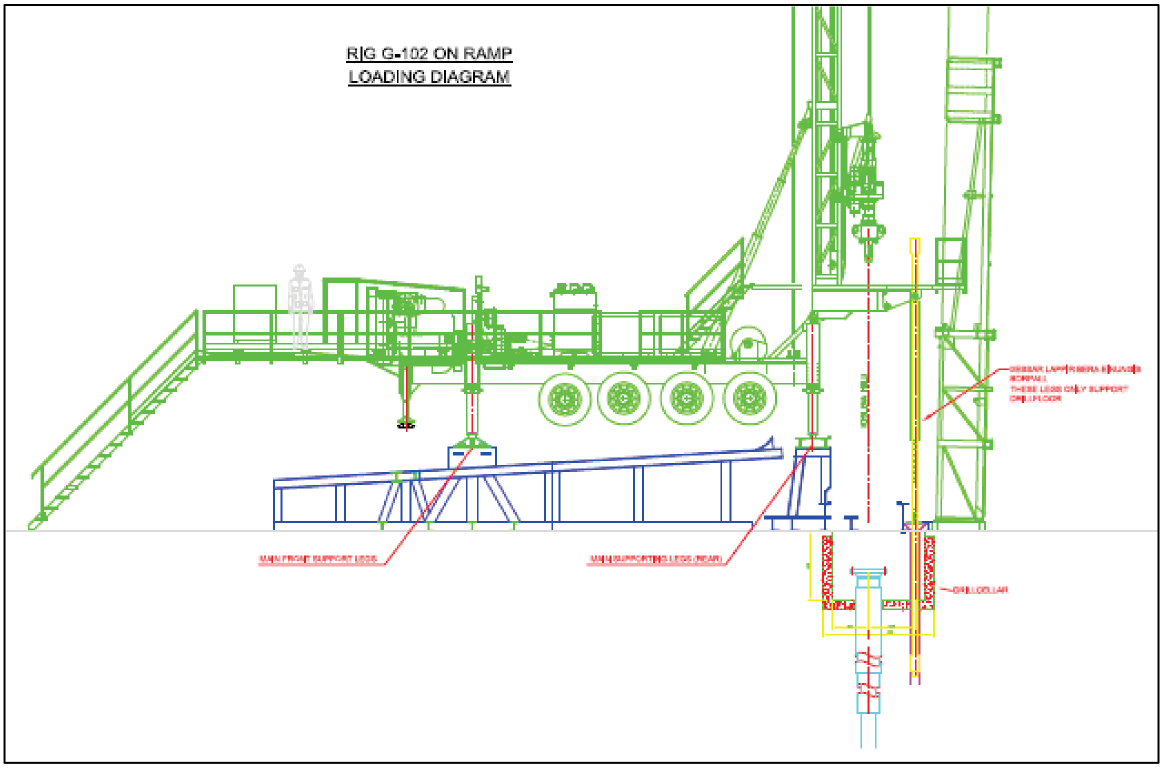
- Drill rig, generator, and drilling mud mixing/separation facility;
- Mud pond to store the mixed drilling mud and cuttings (i.e, ground rocks removed from a well or borehole during drilling);
- Geothermal fluid pond to store the fluid; and
- Auxiliary facilities (e.g., a waste storage area, potable water tank, fuel tank, office, laboratory, mess unit, material storage area, mechanical and electrical workshop container, septic tank, and parking area).

The Project will use one drill rig. The drill rig will be a trailer-mounted, hydraulic-powered top drive rig controlled by four hydraulic motors with a diesel engine, with a total power of 1500 break horsepower. The rig mast will be 20 m to 25 m tall (see Figure 3-7). The drill rig includes the above-mentioned engine and hydraulic components as well as control equipment, mud pumps, and drilling mud mixing/separation system. The Drilling Contractor will set up the drill rig (see Figure 3-8), test the drill rig, and establish the auxiliary facilities on the drill pad. The Drilling Contractor will install a temporary septic system on the drill pad for domestic water management, in accordance to national standards and international best practice.



Source: Stantec 2015

Figure 3-7: Example Drill Rig



Source: Stantec 2015

Figure 3-8: Cross Section of the Installed Drill Rig

Each exploration drill pad will have three exploration wells, see Figure 3-9 and Figure 3-10. The exploration wells can operate in the future as production wells if they yield the desired results. Wells will be drilled using directional drilling with tricone TCI drill bits. The three W1 exploration wells will have an estimated depth of up to 2,500 m. Tables 3-2 to 3-4 provide dimensions and proposed depths of the W1 wells: SVG-01, SVG-02, and SVG-03. The design and characteristics of the three W3 exploration wells have not been confirmed but it is estimated they will have similar characteristics as the W1 wells.

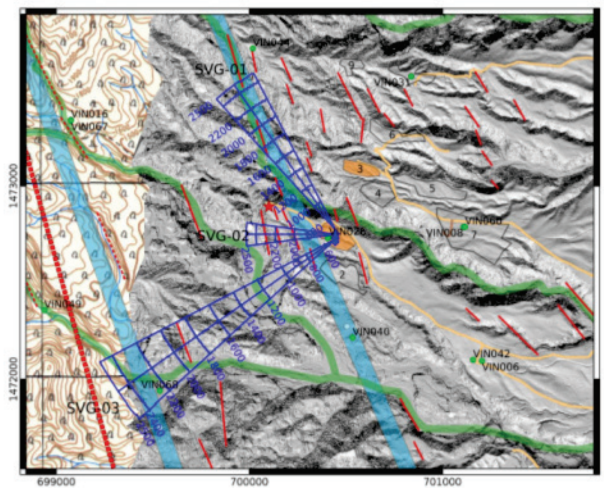


Figure 3-9: Drill Pad W1 with Three Proposed Wells

Source: RG 2015a

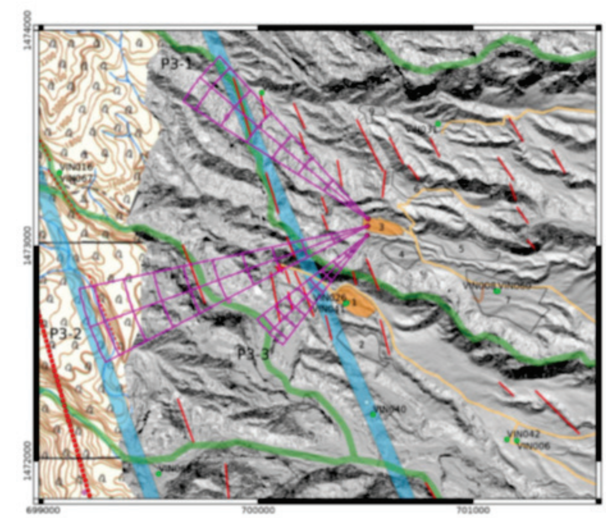


Figure 3-10: Drill Pad W3 with Three Proposed Wells

Source: RG 2015a

Drilling operations will occur 24 hours a day. The Drilling Contractor will conduct the drilling activities by using conventional drilling technology, drilling with progressively smaller drill bits as the sections become deeper. Each diameter drill will include steel casings "string" to maintain well integrity, prevent interaction with the surrounding aquifer, and control the drilling fluids. During drilling, the Driller Contractor will move and install casings and drill sections using onsite cranes. The Driller Contractor will mix cement onsite with water, silica flour, and other additives. The Drilling Contractor will pump the cement in the annular space between the casing and the open borehole after inserting the casing string. A slotted design will be included into the final casing string, not cemented, to let the geothermal liquid flow inside the well up to the surface. Once the Drilling Contractor drills the exploratory wells, they will install a silencer and a wellhead valve system to prevent blowouts and control the flow of gases and geothermal liquid during testing.

Table 3-2: Basic Exploration Well Data, SVG-01

Hole and Casing Details	1 Stage Surface Casing	2 Stage Anchor Casing	3 Stage Production Casing	4 Stage Perforated Liner
Hole diameter (inches)	26	17.5	12.25	8.5
Hole depth (meters)	0-150	0-790	0-1770	1740-2500
Vertical depth (meters)	0-150	0-770	0-1620	1590-2250
Casing and Liner (inches)	20	13.375	9.625	7
Weight (pound/foot)	94	68	47	26
Grade	K55	K55	K55	K55
Threads and Collars	Buttress	Buttress	Buttress	Buttress
Approximate number of joints	13	66	148	64
Casing Cementing	Cemented to surface	Cemented to surface	Cemented to surface	Not cemented

Expected maximum wellhead pressure: 87 bar; Expected maximum formation temperature: 310 ºC and well fluid: hot water/steam

Source: Adapted from Request for Proposals St. Vincent Geothermal – Drilling Phase, RG and EC 2016

Table 3-3: Basic Exploration Well Data, SVG-02

Hole and Casing Details	1 Stage Surface Casing	2 Stage Anchor Casing	3 Stage Production Casing	4 Stage Perforated Liner
Hole diameter (inches)	26	17.5	12.25	8.5
Hole depth (meters)	0-150	0-700	0-1870	1840-2500
Vertical depth (meters)	0-150	0-700	0-1840	1810-2380
Casing and Liner (inches)	20	13.375	9.625	7
Weight (pound/foot)	94	68	47	26
Grade	K55	K55	K55	K55
Threads and Collars	Buttress	Buttress	Buttress	Buttress
Approximate number of joints	13	59	156	55
Casing Cementing	Cemented to surface	Cemented to surface	Cemented to surface	Not cemented

Expected maximum wellhead pressure: 75 bar; Expected maximum formation temperature: 300 ºC and well fluid: hot water/steam

Source: Adapted from Request for Proposals St. Vincent Geothermal – Drilling Phase, RG and EC 2016

Table 3-4: Basic Exploration Well Data, SVG-03

Hole and Casing Details	1 Stage Surface Casing	2 Stage Anchor Casing	3 Stage Production Casing	4 Stage Perforated Liner
Hole diameter	26	17.5	12.25	8.5

Hole and Casing Details	1 Stage Surface Casing	2 Stage Anchor Casing	3 Stage Production Casing	4 Stage Perforated Liner
(inches)				
Hole depth (meters)	0-150	0-760	0-1870	1840-2500
Vertical depth (meters)	0-150	0-715	0-1565	1540-2050
Casing and Liner (inches)	20	13.375	9.625	7
Weight (pound/foot)	94	68	47	26
Grade	K55	K55	K55	K55
Threads and Collars	Buttress	Buttress	Buttress	Buttress
Approximate number of joints	13	64	156	55
Casing Cementing	Cemented to surface	Cemented to surface	Cemented to surface	Not cemented

Expected maximum wellhead pressure: 77 bar; Expected maximum formation temperature: 300 ºC and well fluid: hot water/steam

Source: Adapted from Request for Proposals St. Vincent Geothermal – Drilling Phase, RG and EC 2016

After drilling in sequence the three exploration wells, the injection well will be the drilled. Injection pads will be located approximately 500 m downhill of the drilling pad. Each injection pad will include only one injection well, which will inject the extracted geothermal liquid through a pipeline that will connect the main exploration drill pad with the injection pad. Table 3-5 provides dimensions and depths of the proposed W1 injection well: SVGR-01. The design and characteristics of the W3 injection well has not been confirmed, but it is estimated that it will have similar characteristics as the W1 well.

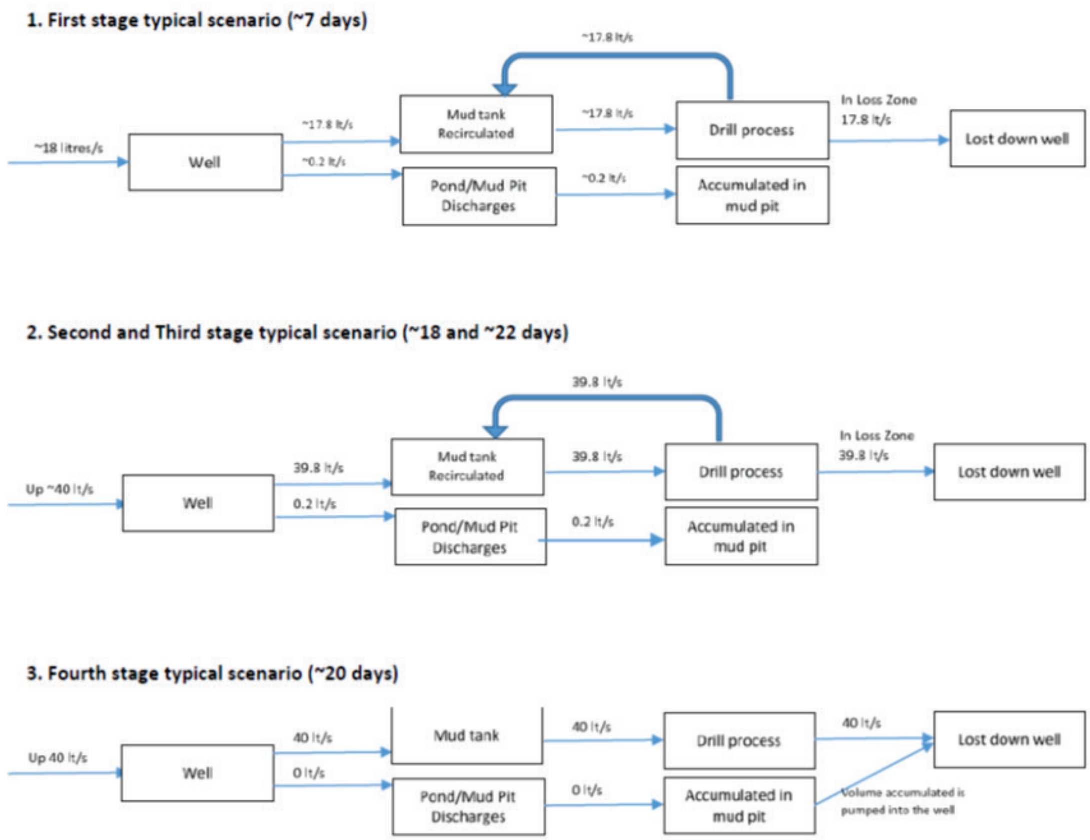
Table 3-5: Basic Injection Well Data, SVGR-01

Hole and Casing Details	1 Stage Surface Casing	2 Stage Production Casing	3 Stage Open Hole
Hole diameter (inches)	26	17.5	12.25
Hole depth (meters)	50-100	~300	~1000
Vertical depth (meters)			
Casing and Liner (inches)	20	13.375	N/A
Weight (pound/foot)	94	68	N/A
Grade	K55	K55	N/A
Threads and Collars	Buttress	Buttress	N/A
Approximate number of joints	5-9	25	N/A
Casing Cementing	Cemented to surface	Cemented to surface	N/A

Source: RG and EC 2016

N/A = not available

Drilling operations will require approximately 5,500 liters (L) of diesel per day. Drilling also requires water and bentonite clay combined with other ingredients (i.e., polymers, lignite, and other additives) to form a drill fluid referred to as "mud". The mixture serves as a lubricant during drilling operations. Most of this water-based drilling mud can be recycled (see Figure 3-11), but in some cases, it is common to lose considerable amounts of drilling mud down the well to the surrounding rock due to porosity or fissures. The Driller Contractor will measure and report the mud properties according to the American Petroleum Institute (API) Rp13B-1 practice (*Recommended Practice for Field Testing Water-based Drilling Fluids).* At the final stage of drilling (Stage 4), when all fluids are lost to the well, water will serve as a lubricant for the drill bit instead of mud. Figure 3-11 presents estimated water consumption and recirculation stages for the Project drilling operations.



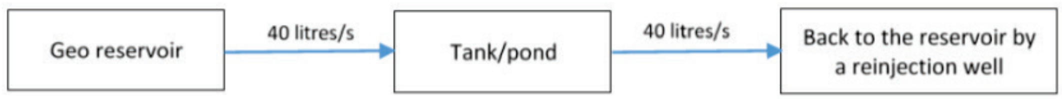
Source: Nippon Koei *et al.* 2015

Figure 3-11: Water Consumption and Recirculation Stages

3.3.4 *Exploratory Testing*

This activity will last between 1 and 3 months, during which the Drilling Contractor will leave the exploratory wells to vent or blow in order to determine and evaluate the characteristics of the geothermal reservoir.

Testing will produce approximately 40 L/s of brine water (see Figure 3-12) and result in gas emissions (carbon dioxide [CO_2], hydrogen sulfide [H_2S], and nitrogen [N_2]). The brine water, usually with high concentrations of minerals and chemicals, will not be discharged to surface waters but will be injected in the injection well. If needed, the lined mud pond will temporarily store the brine water collected from the exploration wells until the injection well begins operating. Gas detectors will be strategically located for H_2S and CO_2 detection. The Drilling Contractor will train all personnel onsite in responding to gas pollution incidents and provide H_2S detectors if personnel will work close to the well or mud tanks.



Source: Nippon Koei *et al.* 2015

Figure 3-12: Diagram of the Test Phase Geothermal Liquid Flow

Well blowouts due to steam pillows developing above the groundwater surface or sudden releases of overburden pressure are nowadays rare given the technological improvement of well construction (Bayer *et al.* 2013). During the testing activity, the Driller Contractor will install Blowout Preventers (BOPs) stack above the exploration wells to reduce the risk of well blowouts due to higher depth pressure than pump pressure and hydrostatic pressure of the mud. All handling and testing of BOP equipment will be in accordance with API 53:2015 (*Blowout Prevention Equipment Systems for Drilling Wells*). Additionally, the top well valve will meet best international standards to withstand the pressures that can be expected on the wellhead.

3.3.5 Decommissioning

In case the results obtained from testing indicate that the exploration wells are not suitable for production, the equipment and material will need to be decommissioned according to Environmental and Social Management Plans described in this ESIA (see Chapter 6.0).

The Drilling Contractor would close and clean up the drill sites and transport the drill rig and other equipment to Kingstown Port, to send the equipment back to its country of origin. SVGCL would fill in any ponds or pits and level and revegetate the pad area with fast-growing species that are common in the Project area including *Gliricida sepium*, *Chrysopogon zizanioides*, and bamboo (multiple species can be used).

3.4 EQUIPMENT AND MATERIALS

Table 3-6 presents the equipment and materials require for the different activities associated with Phase I.

Table 3-6: Phase I Material and Equipment

Activity	Equipment	Material or Additives
All activities	Potable water tank, fuel tank, mechanical and electrical workshop containers, cementing unit (including mixer and pumps), vertical cement containers, 4-wheel drive vehicles, trucks for material transportation (articulated, lift truck, and low boys)	Water, diesel
Upgrading roads	1 or 2 excavators, a grader, trucks for delivery of material, rollers, and paving machine	Asphalt/ bitumen, sub-base material, diesel
Clearing and grubbing; and Earthworks	Excavators	Diesel
Auxiliary facilities (i.e., water supply systems and mud system, office, laboratory and laydown areas, parking areas)	Diesel or electric driven water pumps; HDPE pipes; excavators	Diesel
Drilling and testing	BOPs, discharge/test ponds Drilling rig, train of vehicles, low boys and cranes, mud pumps, mud separation system (including shale shaker, and desilter) Tricone roller cone bits, PDC drill bits, directional drilling, drill rig, including generators and other ancillary equipment pipe casings and other consumables 50-tons cranes (2), generator set, 3 triplex pumps, water tank, mud tanks and mixing tank for mud, casings and casing accessories, wellhead items	Diesel, concrete, bentonite clay, polymers, lignite, additives, water, silica flour

BOP = blowout Preventer; HDPE = high-density polyethylene; PDC = polycrystalline diamond compact

3.5 WORKFORCE

A local contractor or the Ministry of Transport, Works, Urban Development and Local Government will conduct the works related to upgrading the feeder roads. This activity will require small teams of workers (1 or 2). Pad preparation civil work and earthwork will require 10 to 15 workers, all locally hired. Drilling will require between 30 and 40 workers (approximately 30 percent local workers) on three rotation shifts. In addition, the construction of auxiliary facilities will employ local workers as supporting staff (e.g., drivers, flagmen). Worker's accommodations will be located at nearby communities where rooms and houses can be rented.

3.6 SCHEDULE

Table 3-7 presents a summary of the estimated timeline to conduct Project activities.

Table 3-7: Phase I Schedule by Activity

Activity	Estimated Time
Access improvement	2-3 months
Land transportation	Up to 5-7 days
Drill site preparation	Up to 4 months
Drill rig installation and drilling	55-60 days, per well
Exploratory blow testing	1-3 months, per pad
Decommissioning of drilling equipment	14 days

3.7 PROJECT CONTROLS

SVGCL has already taken into consideration potential environmental and social impacts as part of their site selection process (see Section 3.2). In addition, SVGCL has adopted various physical or procedural measures to avoid or minimize environmental impacts as part of the Project design (see Sections 3.3 to 3.5). These measures are referred to as "embedded controls," which are treated as part of the proposed Project and taken into consideration when evaluating environmental and social impacts. Many of these measures are referenced in Sections 3.3 to 3.5; they are also listed below in Table 3-8 and documented as Project "commitments" by SVGCL.

Table 3-8: Phase I Embedded Control Commitments

Embedded Control	Environmental and/or Social Benefit	Resource Protected
Limit size of drill rig	To avoid impacts to Byrea tunnel and Orange Hill Aqueduct	Cultural Heritage
Provide escort vehicles and flagmen	To improve public safety during transport of drill rig to pad sites	Community Health, Safety and Security
Upgrade Windward Highway relative to curves and slopes	Improve road system	Traffic and Community H&S
Provide stormwater management	To allow sediment to settle out prior to release of stormwater to natural water courses	Water Resources and Aquatic Habitat and Species
Provide erosion and sediment control	To minimize soil erosion and the release of sediments to natural watercourses	Water Resources and Aquatic Habitat and Species
Construct a lined mud pond	To collect drill cuttings and recycle drill muds to minimize project water demand	Water Resources and Aquatic Habitat and Species
Provide a security fence around the drill and injection pads	Protect community safety	Community Health, Safety, and Security
Install geotechnical membrane under drill and injection pads	Protect soil resources and minimize risk of land slide	Soils and Community Health, Safety and Security
Provide well casings	Protect groundwater quality	Water Resources
Install silencer and wellhead valve system	Prevent blowouts and reduce noise emissions	Occupational and Community H&S and Noise Terrestrial Species
Use non-toxic drill muds in accordance with *Recommended Practice for Field Testing Water-based Drilling Fluids*	Minimize risk of groundwater contamination	Water Resources
Inject brine water rather than discharge to a stream	Protect ground and surface water quality	Water Resources
Provide H_2S detectors at drill pad and training to workers	Protect worker and community health	Occupational and Community H&S
Install blow out preventers in accordance with *Blowout Prevention Equipment Systems for Drilling Wells*	Protect worker and community health	Occupational and Community H&S Community Health, Safety, and Security
Hire local workers to the extent possible	Maximize local project benefits and minimize impacts associated with use of foreign labor	Community Health, Safety, and Security

H&S = Health and Safety

3.8 *AREA OF INFLUENCE*

Following the International Finance Corporation (IFC) Performance Standards' definition, the Project's Area of Influence (AoI) was determined by:

- Project footprint – exploration drill pads, injection pads, water storage ponds, injection pipeline, water supply pipeline, and feeder roads;

- Project water source – Rabacca River, from the water extraction source to the river outlet into the Caribbean Sea;
- Distance to which Project noise (especially from drilling and blow testing) is estimated to affect nearby receptors –500 m; and
- Nearby settlements to be directly affected (e.g., traffic, potential worker housing, where Project area farmers reside) by the Project – Sandy Bay (also known as Sandy Point), Overland, Tourama, Orange Hill, Waterloo, Langley Park, and Georgetown.

Figure 3-13 presents the Project AoI.

Page intentionally left blank.

4.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

This Chapter describes the baseline (i.e., current) conditions of physical, biodiversity, socioeconomic, and cultural resources in the St. Vincent Geothermal Project Phase I (the Project) Project Area (i.e., 2 km^2 square area where the main Project components would be located; see Chapter 3.0, *Description of the Proposed Project*).

The baseline characterization has the following objectives:

- Identify the key conditions and sensitivities in the Project Area;
- Provide data to support the prediction and evaluation of possible impacts of the Project;
- Understand stakeholder concerns, perceptions, and expectations regarding the Project;
- Facilitate development of appropriate mitigation measures to alleviate or, if needed, compensate for impacts of the Project; and
- Provide a benchmark to assess future changes as well as the effectiveness of mitigation measures.

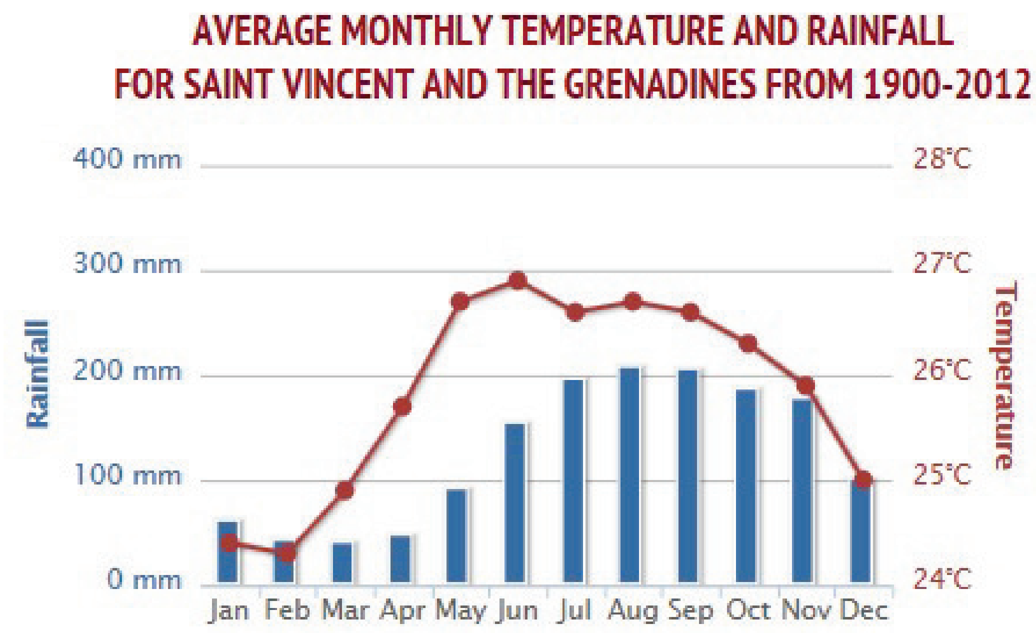
The content of this baseline complies with the *Draft Environmental Impact Assessment Regulations (2009)* for St. Vincent and the Grenadines (SVG).

4.1 PHYSICAL RESOURCES BASELINE

This section describes the existing conditions of geophysical components (i.e., climate, air quality, noise, geology, topography, soils, land use, water resources and natural hazards) located within and near the Project Area. It was developed based on secondary information contained in Project-related material prepared by the St. Vincent Geothermal Company Limited (SVGCL) (e.g., RG 2013, RG and LPH 2013, Murray 2014, Nippon Koei *et al.* 2015); publically available information; data obtained through SVG government entities; and a reconnaissance site visit conducted by ERM on February 2016.

4.1.1 Climate

SVG experiences tropical marine climate with distinct seasonal rainfall patters and relatively mild, stable temperatures. The wet season occurs from June to December, while the dry season occurs for the remainder of the year (December to June). Annual precipitation varies from 1,450 millimeters (mm) in the southern and southwestern portions of SVG to approximately 5,000 mm in the northern, mountainous, and windward regions, where the proposed Project is located. Clouds often cover the Project Area, especially near the La Soufrière Volcano; therefore, rain is more frequent even during the dry season. Figure 4-1 depicts SVG's monthly average rainfall from 1900 to 2012 (World Bank Group 2016).



Source: The World Bank Group 2016

Figure 4-1: Average Monthly Temperature and Rainfall Amounts for SVG, 1900-2012

The wettest months include July, August, and September; the driest months include February, March, and April. There is marginal variation in SVG's annual average temperature, as it ranges from 24 degrees Celsius (°C) to 27 °C. The warmest temperatures occur during the months of May and June, while the coolest months are January and February.

Table 4-1 provides a summary of minimum and maximum relative humidity and air temperature values from March 2009 through October 2015 near the Project Area (Rabacca Climate Change Station).

Table 4-1: Rabacca Climate Station Data (March 2009 - October 2015)

Climate Parameter	2009		2010		2011		2012		2013		2014		2015		2009-2015	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Relative Humidity (%)	53.0	97.8	53.7	100.1	-2.7	125.4	58.4	99.9	53.5	99.9	43.7	99.9	42.5	99.9	43.2	103.3
Temperature (°C)	20.5	32.1	20.9	33.3	19.9	32.7	20.4	32.4	20.7	30.0	21.1	33.3	21.0	31.6	20.6	32.2

% = percent, ˚C = degree Celsius, Min. = minimum, Max. = maximum

Source: CWSA 2015

Note: Station Number: 30100001; Elevation 59 meters

SVG's climate is influenced by the North East Trade Winds, which consistently blow 15 to 25 knots most of the year, with gusts of up to 30 knots between December and February (known locally as the Christmas Winds). These winds generally have east to east-southeast direction and are constant throughout the year.

Severe weather events in SVG include high winds, flash floods, coastal floods, and storm surges associated with tropical rainstorms and hurricanes that occur mainly during the rainy season (see Section 4.1.7, *Natural Hazards,* for more details). Flash floods and their associated landslides and mudflow during tropical rainstorms have been identified as a concern in the coastal area between Orange Hill and Georgetown. There are three hurricane tracks in the Caribbean, and SVG is located within the Eastern Caribbean track (Caribbean Hurricane Network 2011). Between 1900 and 2013, SVG was affected by 14 major hurricanes. Hurricane Janet (1955) was responsible for 122 fatalities and widespread damage to properties and crops; Hurricane Emily (2005) damaged approximately 500 homes; and Hurricane Tomas (2010) damaged over 1,200 properties and resulted in significant damage to infrastructure and crops. In December 2013, a major flood occurred that damaged many areas of SVG which had an estimated cost of USD$108 million.

As stated in SVG *Intended Nationally Determined Contribution*s, its geography, geology, and socioeconomic characteristics make SVG "extremely vulnerable to climate-related natural disasters" (SVG 2015). The country's population and socioeconomic activities are mostly concentrated on the narrow, low-lying coastline, which considered at risk to sea-level rise and coastal erosion. The mountainous topography adds risks of landslides and flash flooding. Climate projections suggest an increase in average temperature, reduced average annual rainfall, increased sea surface temperatures, and the potential for an increase in the intensity of tropical storms (SVG 2015). This would have important effects on agriculture, water availability, and infrastructure.

4.1.2 *Air Quality*

Air quality data for SVG is limited; in addition, there is no specific data available for the Project Area or surroundings. However, it can be presumed that the ambient air quality in the Project Area and its vicinity is good because the area is generally undeveloped and corresponds to cropland and forest. The area also receives frequent winds and precipitation. There are no major industrial sources of emission in SVG and no residential developments near the Project Area. Few vehicles access the Project Area or its vicinity; those that do are mostly for tourism activities. The feeder roads are paved and surrounded by vegetation, which result in low dust generation.

In the event of La Soufrière Volcano eruptions, SVG's air quality would be extremely poor due to volcanic ash. High levels of particulates and gases such as sulphur dioxide (SO_2), hydrogen sulfide, steam, carbon monoxide, and carbon dioxide (CO_2) could enter the atmosphere and the Project Area. La Soufrière Volcano last erupted in 1979 and mass emissions of SO_2 entered the atmosphere, which resulted in a mean value of 339 ± 126 metric tons per day (Murray 2014). For comparison, in 2000 the World Health Organization (WHO) provided ambient air quality guidelines for sulfur dioxide of 125 micrograms per cubic meter ($\mu g\ m^3$) average in a 24-hour period (IVHHN 2016). SVG's ambient air quality is therefore affected by volcanic activity (i.e., non-anthropogenic or natural sources).

According to the *Initial National Communication on Climate Change*, SVG is considered a net sink (i.e., has negative contributions to global CO_2) for greenhouse gases (National Environmental Advisory Board *et al.* 2000).

4.1.3 Noise

In general, noise sources in the Project Area correspond mainly to rural settlements and low and moderate traffic. The Project Area presents no industrial noise generating sources or large settlements.

ERM conducted ambient noise level measurements during the Environmental Impact Assessment complementary field survey from 21 February to 25 February 2016 at seven noise measurement locations (NMLs). ERM collected noise measurements to characterize the baseline acoustic environment in the Project Area and vicinity. See Appendix A, *Noise*, for a detailed discussion of the methodology used by ERM during field measurement and data collected during the survey.

The objective of the survey was to quantify the ambient noise levels within and in the vicinity of the Project Area and verify the current noise sensitive areas, such as residences, schools, hospitals, long-term care facilities, places of worship, libraries, parks, wilderness areas, and recreational areas valued specifically for their solitude and tranquility. A description of each NML and its distance to future Project components are provided in Table 4-2. Figure 4-2 shows each NML location.

Table 4-2: NML Descriptions and Distances to Project Components

NML	Description of Receptor	Distance to Nearest Project Component(s) or Referential Location
N1	Located along the Windward Highway, adjacent to the Orange Hill Aqueduct and an operational mental health facility.	W3 RP: 2 km Windward Highway: 5 m
N2	Along the Windward Highway at the entrance to the New Orange Hill Horticulture Research and Development facility; Across the road from the community of New Orange Hill.	W3 RP: 2.1 km Windward Highway: 5 m
N3	Adjacent to the Bamboo Range Visitor Center; Visitor center includes park staff building, bathrooms, and picnic areas; Used by locals and tourists for daytime recreation.	W1 DP: 247 m
N4	Rural roadside across the road from a farm worker building; Building is semi-permanently occupied, with laborers occupying the structure, including sleeping, while tending to nearby agricultural fields/plantations.	W1 DP: 60 m W1 FR: 5 m
N5	Agricultural field adjacent to farmer laborer camp; Camp is occupied during the day by laborers working in adjacent fields; Appears to be used for daytime breaks and meals but may be occupied overnight on some occasions.	W1 RP: 0 m W1 FR: 100 m
N6	Located next to a house that is currently under construction; Residents of the planned house were relocated to this location because their previous home was adjacent to Well Pad 3.	W3 RP: 0 m W3 FR: 20 m
N7	Rural roadside adjacent to banana processing structure; Structure used by plantation laborers during the day to clean and process bananas, work breaks, and meals.	W3 DP: 88 m W3 FR: 5 m

DP = drill pad; FR = feeder road; m = meter; NML = noise measurement location; RW = Injection pad

Noise measurements were recorded during the daytime (07:00 to 22:00 hours) at all seven NML locations, and nighttime measurements (22:00 to 07:00 hours) were collected at five of the seven locations.[vii] Nighttime measurements were collected at locations that were adjacent to facilities or structures believed to be used or occupied during the night.

SVG does not have national noise standards. Therefore, ERM used the International Finance Corporation (IFC) *General Environmental, Health, and Safety (EHS) Guidelines* (IFC 2007) noise level thresholds to assess current baseline noise conditions (see Table 4-3). The IFC EHS Guidelines state that noise impacts from a project should not exceed the levels presented in Table 4-3 or result in a maximum increase in background levels of 3 decibels (dB) at the nearest receptor location.

Table 4-3: IFC EHS Guidelines for Noise Level Thresholds

Receptor	IFC EHS Guidelines (1 Hour L_{Aeq}) (dBA)	
	Daytime (7:00-22:00)	Nighttime (22:00-7:00)
Residential; institutional; educational	55	45

[vii] Nighttime data was not collected at locations that were not used during the night. For example, nighttime measurements were not collected at the Bamboo Range Visitor Center because the facility is closed to the public during the night.

Industrial; commercial	70	70

Source: IFC 2007a

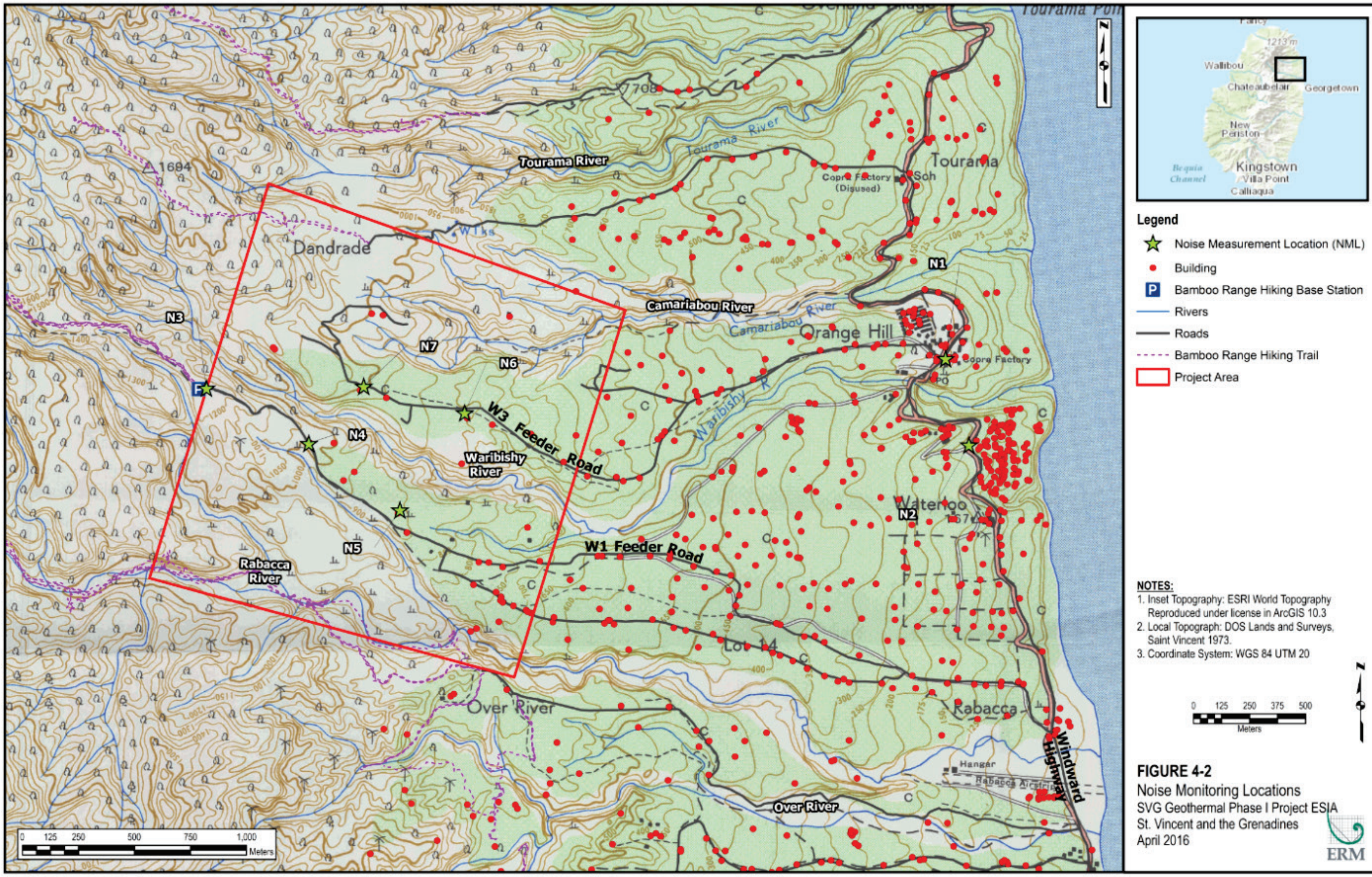


Figure 4-2: Noise Monitoring Locations

Table 4-4 summarizes the results of noise survey conducted by ERM. The recorded noise levels correspond to airborne sound levels in dB. An A-weighted filter was applied to compensate for the frequency response of the human auditory system; as a result, the data is presented in A-weighted decibels (dBA). The data presented in Table 4-4 is the daytime and nighttime steady, continuous equivalent sound pressure level (Leq), which has the same acoustic energy as the actual varying sound levels over the same daytime or nighttime period.

Table 4-4: Measured Ambient Noise Levels

NML	Measured Leq(day) (dBA)	Measured Leq (night) (dBA)
N1	56.8	57.1
N2	61.6	58.8
N3	44.5	--
N4	46.9	43.7
N5	41.6	--
N6	40.6	48.3
N7	39.4	45.4

dBA = A-weighted decibels; Leq = equivalent sound pressure level; NML = noise measurement location

Table 4-4 shows that the equivalent noise levels during daytime vary from 39.4 to 61.6 dBA at the seven NMLs. Nighttime equivalent noise levels ranged from 43.7 to 58.8 dBA at the NMLs.

During daytime, the highest noise levels were recorded at N1 (56.8 dBA) and N2 (61.6), both located along the Windward Highway. Audible daytime noise at both locations were due to noise from frequent vehicle and pedestrian traffic, residents outside of homes talking, wind rustling leaves in trees, and bird calls. Along the feeder roads closer to the proposed exploration drill pad W1 and W3, noise levels were generally lower, ranging from 39.4 (N7) to 46.9 (N4) dBA. Audible daytime noise at these locations included bird calls, farm laborers talking as they passed along the roads, a small number of passing vehicles, and wind rustling leaves in trees.

Nighttime noise levels were either slightly lower than daytime levels or, surprisingly, slightly higher than daytime levels. Nighttime levels recorded at NMLs N1 and N2 were slightly lower (N2) or slightly higher (N1) than daytime levels, but did not vary greatly. This is due to relatively consistent vehicle traffic and activity at the mental health facility during both the day and night recording periods. Nighttime levels at the more rural NMLs (N4, N6, and N7) showed similar variability. At N4, the recorded noise Leq dropped from 46.9 dBA during the day to 43.7 dBA at night. At N6 and N7, the dBA levels increased from 40.6 to 48.3 dBA at N6 and from 39.4 to 45.4 dBA. This is likely due to the increased noise from birds, insects, and wind rustling leaves observed during the nighttime compared to the stiller wind conditions and decreased wildlife noise during the day.

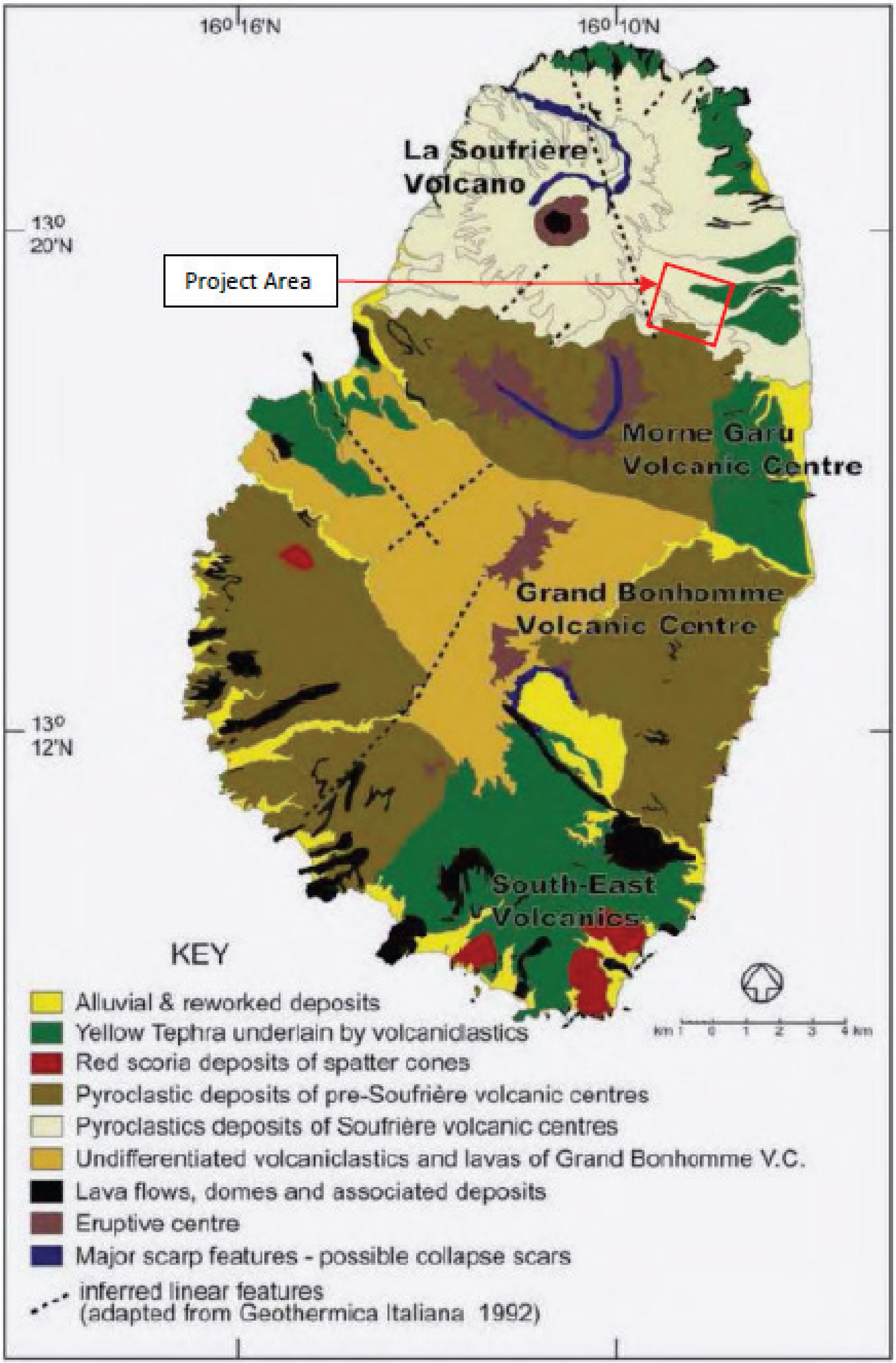
IFC EHS Guidelines classifies all NMLs as residential, institutional, or educational (IFC 2007). The baseline noise survey indicates that noise levels at N1 and N2 currently exceed the IFC EHS Guidelines daytime noise limit of 55 dBA. The recorded noise levels at the remaining five NML were below the IFC EHS Guidelines threshold. The baseline survey indicates that nighttime noise levels at four of the five NMLs exceed the IFC EHS Guidelines threshold of 45 dBA. NML N4 was the only location where nighttime noise levels were below the threshold.

4.1.4 Geology and Topography

The geology of the island of St. Vincent is characterized by high volcanism, volcanic rocks, landforms, and landscapes associated with the Antillean Arc. The geologic formations are approximately 50 million years old and of predominantly volcanic origin. Some formed approximately 3 million years ago, with the youngest rocks formed during the eruption of La Soufrière Volcano in 1979.

The main exposed rock types are sedimentary (impure limestone and coral) and igneous in origin (Roberston 2003). The north area of St. Vincent presents exposed rocks dominated by basaltic-andesites, while basalts are found in the south part of the island. Andesites and xenoliths are also found in St. Vincent. The entire island consists of consolidated rocks (lava flows and dykes) or unconsolidated materials (volcaniclasts). Apart from recent alluvial deposits (e.g., river and beach sand), only igneous rocks are found on the island (Roberston 2003).

St. Vincent is divided into four main geologic regions based on topography, field geology, and geochemistry (see Figure 4-3): South-East Volcanic, Grand Bonhomme; Morne Garu; and La Soufrière Volcano. These volcanic centers followed a similar evolution process; they were initially effusive and produced a substructure of basaltic lava. Periods of phreatic (explosive) followed, producing large strato-cones by depositing layers of ash and scoria. Over the last 3 million years, the strato-volcanic activity and creation of eruptive centers have migrated, ending with the active La Soufrière Volcano located at the north part of St. Vincent. The Project Area overlays the Soufrière Volcanic center, characterized by pyroclastic deposits.



Source: Nippon Koei *et al.* 2015

Figure 4-3: Geological Map of St. Vincent

The mountains (central north-south chain) of SVG were formed by two major volcanic eruptions during the Pleistocene Era. The geomorphology of St. Vincent is a weathered volcanic landscape, typical of a Caribbean island; it consists of a central axial range of mountains starting from La Soufrière Volcano (1178 meters [m]), in the north, to Mount St. Andrew (736 m) to the south. These mountains created numerous valleys that drain to the narrow coastal belt (Nippon Koei *et al.* 2015). According to Roberston (2003), the original volcanic landscape of St. Vincent has been extensively altered due to erosion, tropical climate, steep topography, the unconsolidated nature of the material, and sea level changes.

Topography of St. Vincent is highly undulated with steep river valleys. Approximately 50 percent of the island presents slopes greater than 30 percent and only 20 percent of slopes less than 20 percent. Figure 4-4 shows the topography and slopes of the Project Area located at the base of the La Soufrière Volcano. The Project Area terrain is steep, with maximum slopes of 8 to 16 degrees.

Figure 4-5 and Figure 4-6 show typical landscapes of the Project Area at the proposed exploration drill pad W1 and W3, respectively. The landscape is mainly tropical pastoral with productive fields of crops (e.g., banana, cassava, pigeon peas, sweet potatoes, yams, and arrowroot) and forested hills and valleys.

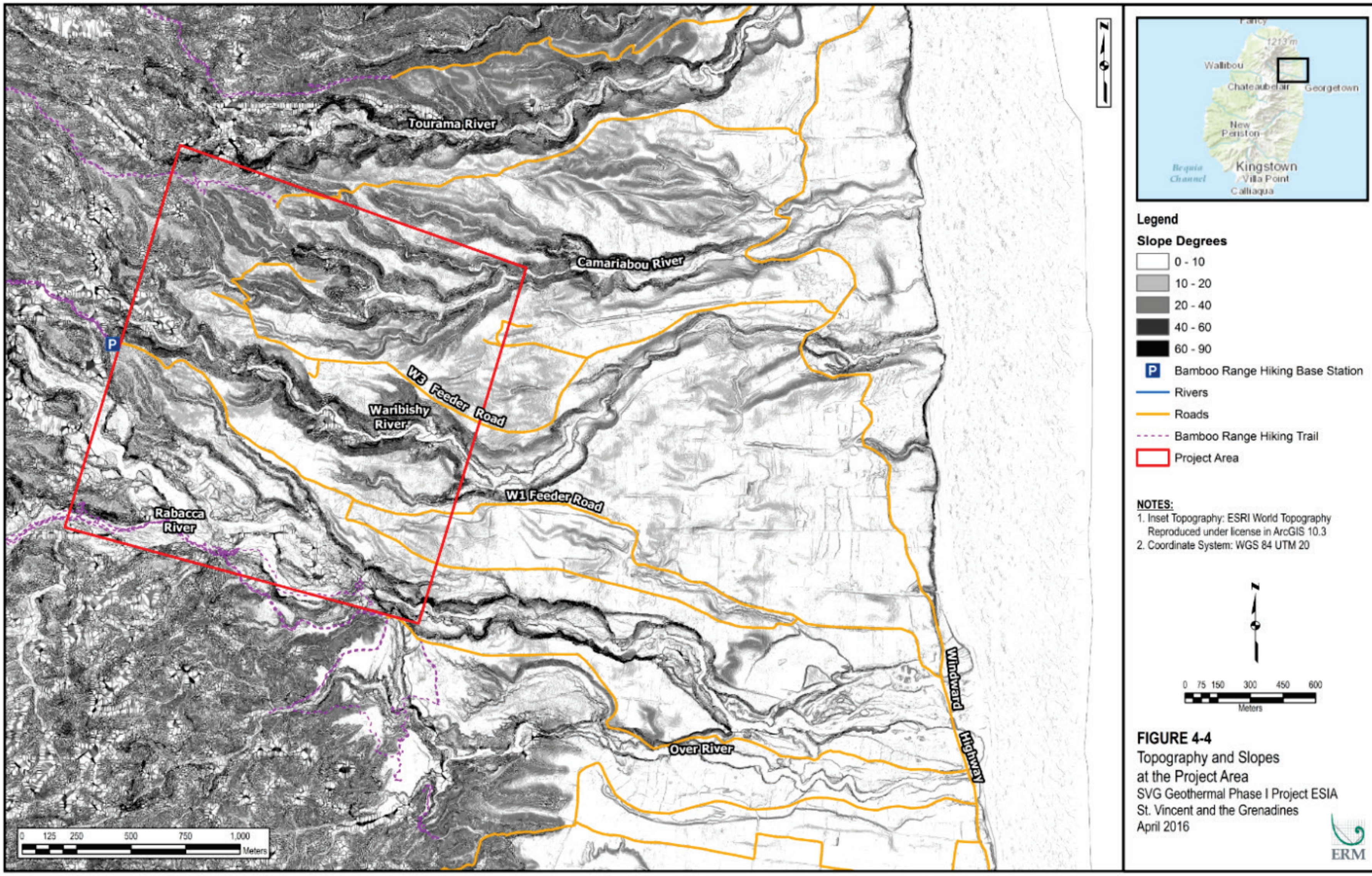


Figure 4-4: Topography and Slopes at the Project Area

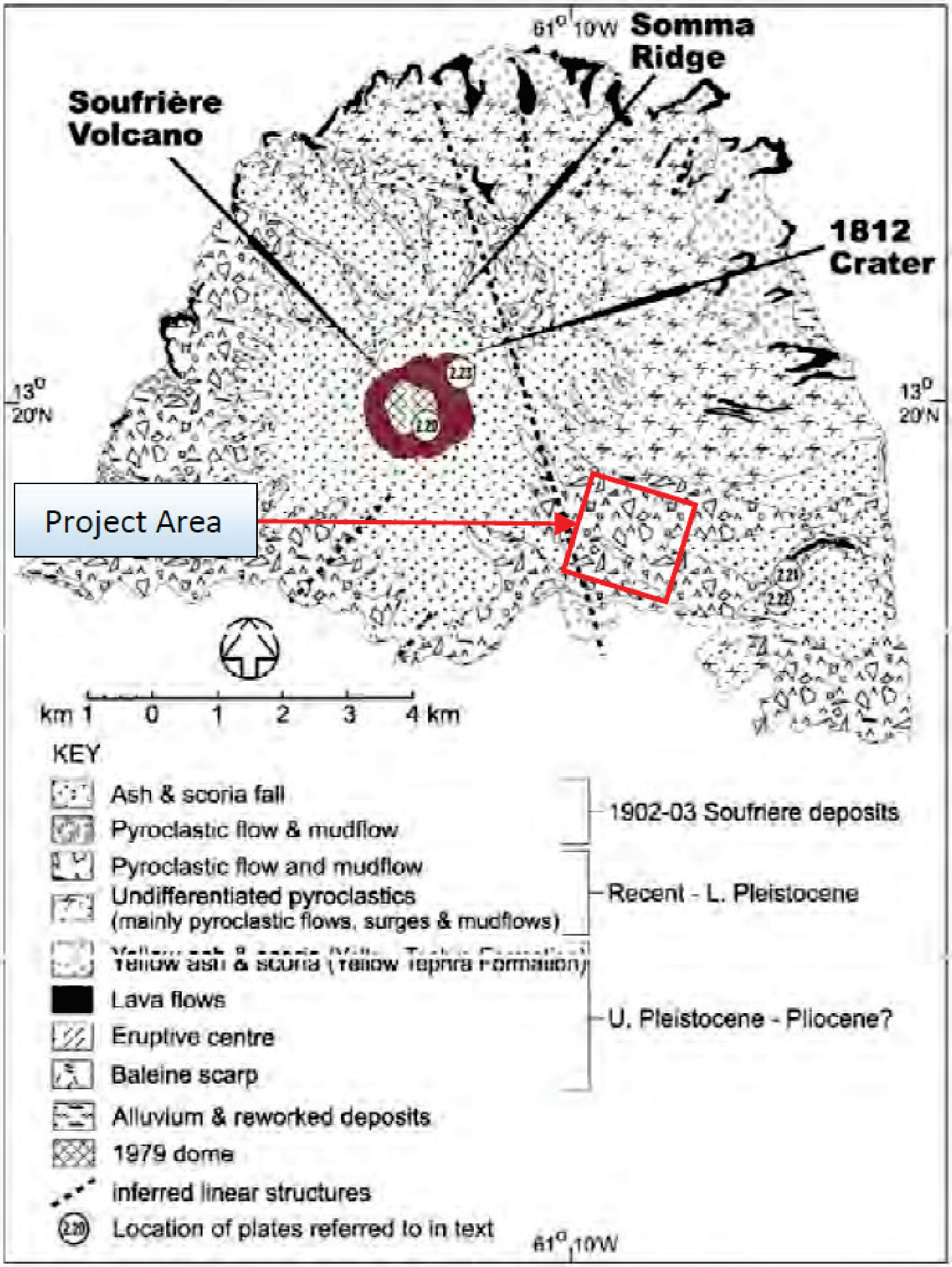
Figure 4-5: Banana Plantation at W1 during Site Visit on February 2016

Figure 4-6: Vegetation at W3 during Site Visit on February 2016

4.1.5 Soils and Land Use

4.1.5.1 Soils

St. Vincent soils are relatively immature, mostly generated from recent volcanic ash, cinders, and rock fragments as reflected in the black sandy beaches. During the eruptions of La Soufrière Volcano in 1828 and 1902, large volumes of coarse volcanic sand were deposited in the north part of the island. This volcanic material make fertile soils; in conjunction with precipitation, the fertile soils support a wide variety of crops. The most common soils in the Project Area are volcanic (Pyroclastic flow and mudflow, see Figure 4-7) – sandy and highly permeable with good drainage potential. However, this results in dryness in some areas. Dominant soil types are "high level yellow earth soils", deeply weathered, leached, and somewhat acidic due to high precipitation in the area. Figure 4-8 shows a soil profile from the visit conducted by ERM in February 2016 at the proposed exploration drill pad W1.



Source: Nippon Koei *et al.* 2015

Figure 4-7: Soil Type in Northern St. Vincent

Figure 4-8: Soil Profile at W1 (February 2016)

4.1.5.2 Land Uses

The Organization of American States (OAS 2001) established that approximately 29 percent of the St. Vincent is covered by forest, of which 70 percent is natural forest, 25 percent is planted forest, and about 5 percent is agro-forest. The Forestry Department of SVG has carried out foresting efforts, reflected by the 25 percent of planted forest. The other main land uses are agriculture, mining (quarrying), and constructed (e.g., houses, roads, hard courts).

The Project Area is located at the north part of St. Vincent where agriculture, forest, and residential are the predominant land uses. Figure 4-9 presents the land cover (assumed to correspond to the land use) in the Project Area: agriculture, wooded scrubland, grassy scrub/pasture, and mature secondary forests. The land use at the proposed exploration drill pads W1 and W3 consist of banana plantations, mango and breadfruit trees, field crops (arrowroot, yams, sweet potato and other vegetables), and scrub/pasture interspersed with tree crops (citrus, banana, mango and coconut).

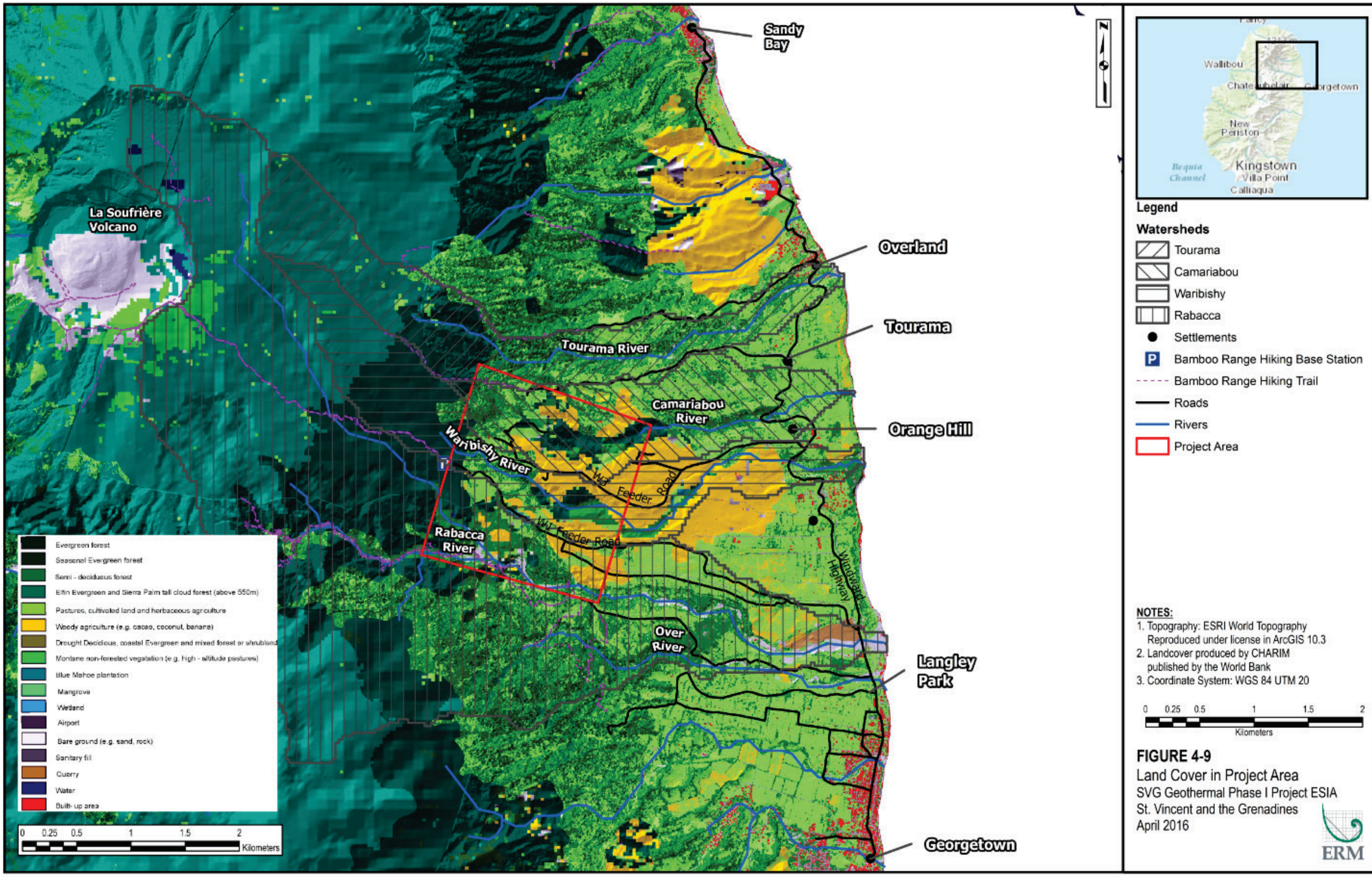


Figure 4-9: Land Cover in Project Area

4.1.6 *Water Resources*

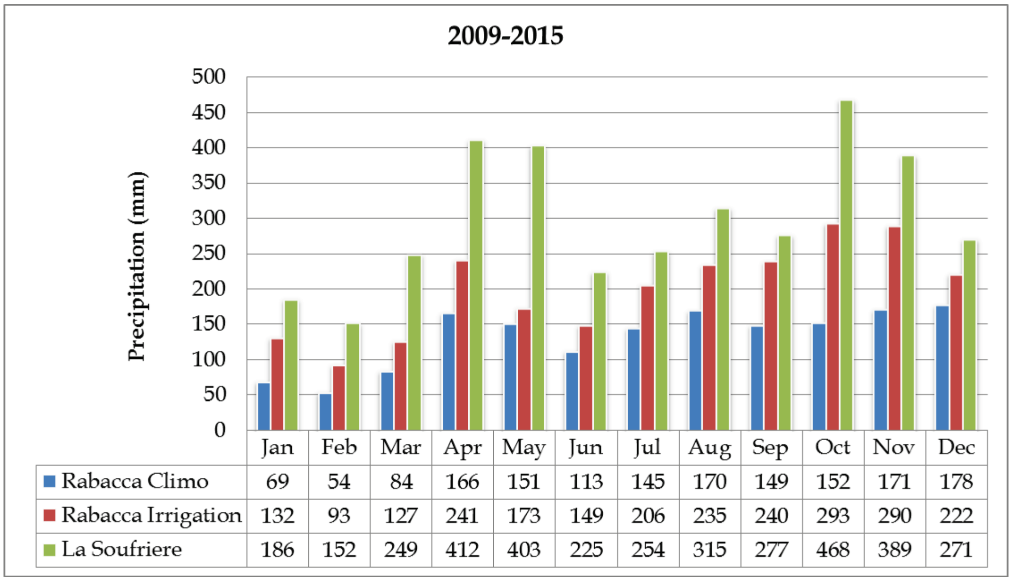
This section describes the existing conditions of surface water and groundwater resources located within and close to the Project Area. The baseline water resources description is based on a desktop review (previous studies) and one site visit that ERM conducted on February 2016. Surface water resources are defined by watersheds, subwatersheds, and rivers or streams crossed by the Project Area. Groundwater characteristics are described based on the local hydrogeology and aquifers located within the Project Area.

The surface and groundwater baseline section is organized as follows:

- Summary of precipitation trends of the watershed where the Project is located;
- Description of the surface water hydrologic baseline conditions of the watersheds and subwatersheds crossed by the area;
- Description of the existing groundwater hydrologic conditions;
- Description of the surface water quality; and
- Identification of water users.

4.1.6.1 *Precipitation*

As mentioned in Section 4.1.1, *Climate*, the wet season in SVG lasts from June to December, while the dry season occurs from December to June. According to precipitation records from La Soufrière Volcano, Rabacca Irrigation, and Rabacca Climo rain gauge stations, the total annual precipitation from 2009 to 2015 at the Project Area ranges between 1603 mm and 3602 mm. Figure 4-10 presents the average precipitation by month recorded at La Soufrière Volcano, Rabacca Irrigation, and Rabacca Climo rain gauge stations, while Figure 4-11 shows their location with respect to the Project Area. According to McSweeney *et al.* (2016), projections of mean annual precipitation for SVG from different climatological models indicate that annual precipitation will vary between -61 percent to +23 percent by the 2090s. In addition, model projections indicate that the decrease in precipitation will be larger in the south than in the north region of SVG.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rabacca Climo	69	54	84	166	151	113	145	170	149	152	171	178
Rabacca Irrigation	132	93	127	241	173	149	206	235	240	293	290	222
La Soufriere	186	152	249	412	403	225	254	315	277	468	389	271

Source: Adapted from CWSA 2015

Figure 4-10: Average Precipitation in the Project Area

4.1.6.2 *Surface Hydrology*

This section includes a description of the hydrologic characteristics of the main watersheds and subwatersheds where the Project is located. The description includes information of the main rivers and streams located within these watersheds/subwatersheds. In addition, a water balance for the Rabacca River watershed was estimated.

4.1.6.2.1 *Watersheds and Subwatersheds*

St. Vincent occupies an area of approximately 348.6 square kilometers (km^2), which is divided into 16 watersheds (Soufrière-Leeward, Soufrière-Windward, Rabacca, Wallilabou, Georgetown, Richmond, Chateaubelair, Cumberland, Colonarie, Peter's Hope, Buccament Watershed, San Souci, Biabou, Union, Montreal, Kingstown). The main rivers in St. Vincent are Richmond, Rabacca, Cumberland, Colonaire, Buccament, and Yambou. The Project is mainly located within Rabacca River, Waribishy River, Camariabou River, and Tourama River watersheds at the north of the island (see Figure 4-11). Table 4-5 presents the main morphological characteristics of these four watersheds, and Figure 4-9 shows land cover characteristics of the four watersheds. Most of the Project Area land cover is agriculture and pastures. The upper parts of the watersheds are forest and blue mahoe plantation while the lower parts of the watersheds are also agriculture and pastures.

Table 4-5: Characteristics of the Watersheds Intersected by the Project

Watershed	Parameter	Units	Value
Rabacca	Drainage Area	km^2	14.4
	Maximum Stream Slope	m/m	0.1048
	Mean Elevation	m	506.3
	Maximum Stream Length	km	9.93
	Perimeter	km	30.1
Waribishy	Drainage Area	km^2	3.1
	Maximum Stream Slope	m/m	0.1141
	Mean Elevation	m	340.2
	Maximum Stream Length	km	6.73
	Perimeter	km	17.9
Camariabou	Drainage Area	km^2	2.45
	Maximum Stream Slope	m/m	0.0977
	Mean Elevation	m	198.0
	Maximum Stream Length	m	3.72
	Perimeter	km	10.7
Tourama	Drainage Area	km^2	3.03
	Maximum Stream Slope	m/m	0.1546
	Mean Elevation	m	456.2
	Maximum Stream Length	m	6.15
	Perimeter	km	17.6

km= kilometers, m= meters; km^2= square kilometers; m/m= meter per meter

Note: Information is based on Digital Elevation Model and the Watershed Modeling System

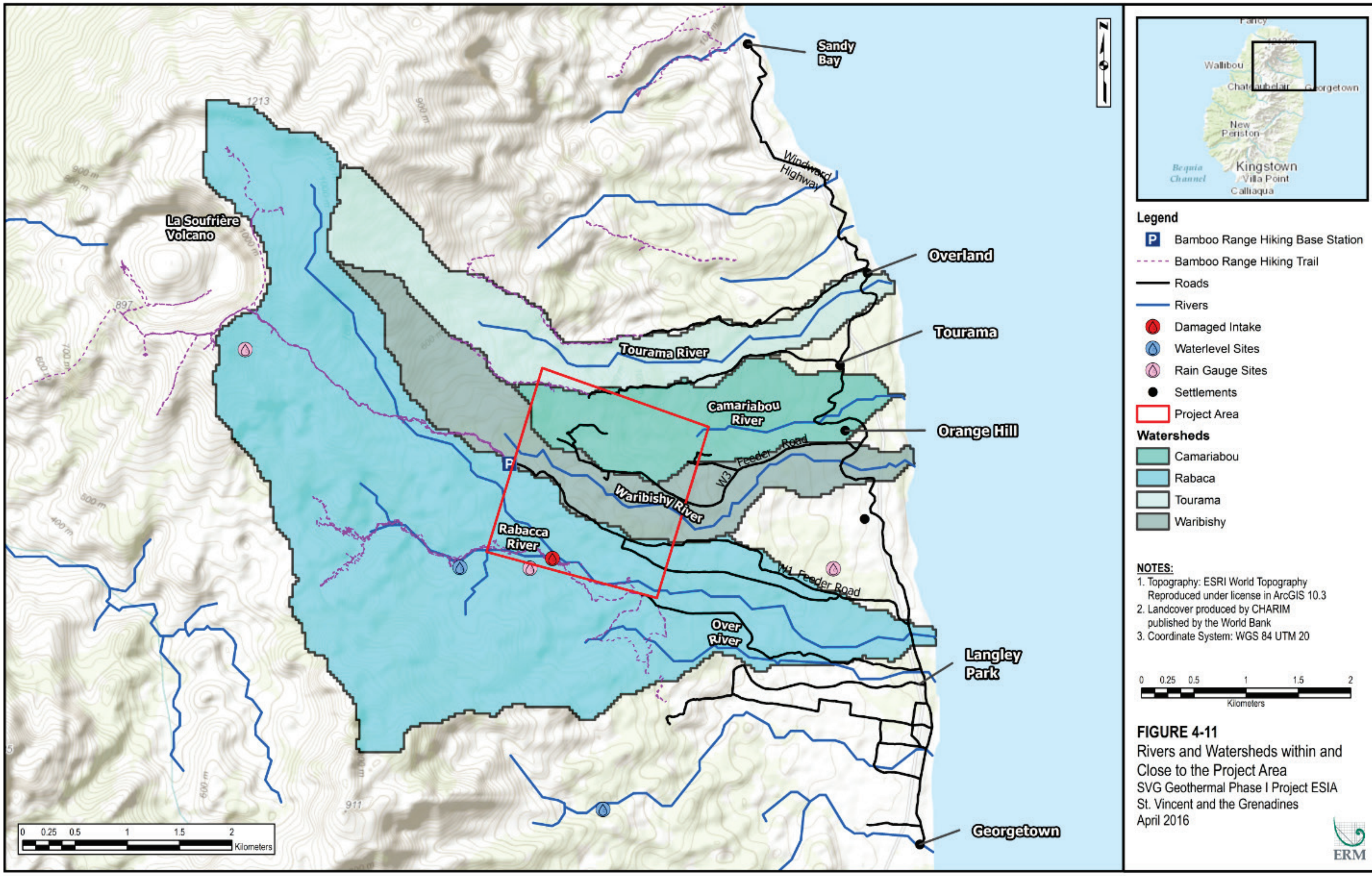


Figure 4-11: Rivers and Watersheds within and Close to the Project Area

4.1.6.2.2 Rivers and Lakes

There are no natural lakes of significant importance in St. Vincent. The main freshwater sources are rivers that drain from the center of the island to the ocean through steep river valleys. However, many of the rivers are perennial, meaning that they reduce their flow during dry season (December to June).

Decrease in precipitation and anthropogenic factors including deforestation and population growth have caused a reduction on river flows. For example, the Rabacca River, which would be used as the main source of water for the Project (see Chapter 3.0, *Description of the Proposed Project*), usually exhibits flow reduction during the dry season (December to June).

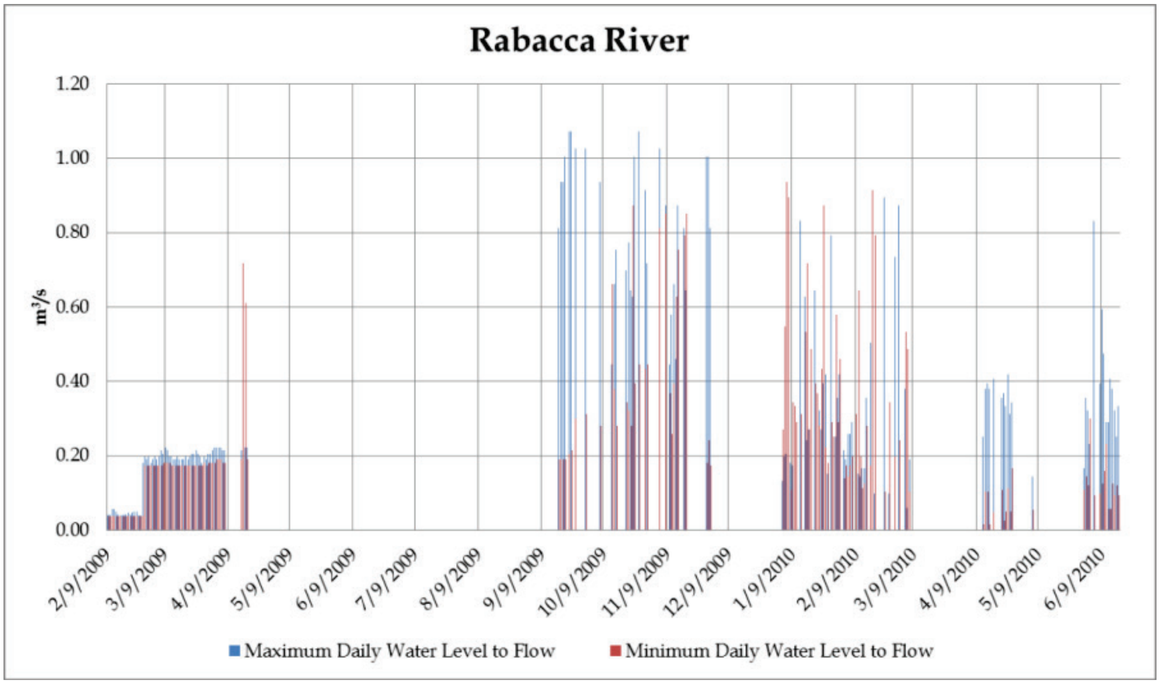
There is limited streamflow data for rivers located within the Project Area. The limited streamflow data and high permeability of the riverbeds makes assessing the current flows of the rivers difficult (Nippon Koei *et al.* 2015). Table 4-6 shows the available maximum and minimum monthly streamflow data measured at the Rabacca level station by the Central Water and Sewerage Authority (CWSA) for the January 2009 through June 2010 period. This station has a drainage area of approximately 5.6 km^2.

Table 4-6: Maximum and Minimum Water Level to Flow

Month	Year	Maximum Flow (m^3/s)	Minimum Flow (m^3/s)
Jan	2009	--	--
Feb	2009	0.198	0.038
Mar	2009	0.223	0.174
Apr	2009	0.223	0.182
May	2009	--	--
Jun	2009	--	--
Jul	2009	--	--
Aug	2009	--	--
Sep	2009	1.072	0.28
Oct	2009	1.072	0.109
Nov	2009	1.026	0.103
Dec	2009	--	--
Jan	2010	0.832	0.015
Feb	2010	0.894	0.011
Mar	2010	0.873	0.011
Apr	2010	0.419	0.012
May	2010	0.167	0.083
Jun	2010	0.832	0.014

Source: CWSA 2015

Figure 4-12 shows time series of daily available maximum and minimum streamflow values measured at the Rabacca River water level station for the 2009 through 2010 period. The Rabacca River transports over a million tons of gravel ever year to the coast.



Source: CWSA 2015

Figure 4-12: Maximum and Minimum Daily Water Flow

4.1.6.2.3 Water Balance

Table 4-7 shows the water balance estimated for the Rabacca River watershed. This water balance was estimated using available historical precipitation data from rain gauges, shown in Figure 4-10, and climatological data measured at the Rabacca Climate Station operated by the CWSA (2015). According to Murray (2014), the surficial volcanic formation of St. Vincent presents high permeability, and all the river watersheds show similar transmitting characteristics. The same study (Murray, 2014) also indicates that approximately 70 percent of the total runoff is derived from groundwater and subsurface storage based on a study conducted for the Richmond River watershed.

Table 4-7: Estimated Water Balance for the Rabacca Watershed

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	% of Precipitation
Precipitation (mm)	132	93	127	241	173	149	206	235	240	293	290	222	2401	100
Losses (mm)	123	112	123	119	118	116	118	114	113	120	117	122	1415	59
Runoff (mm)	9	0	0	107	55	33	88	121	127	173	173	100	986	41

% = percent; mm = millimeter

4.1.6.3 Groundwater

St. Vincent is located in a volcanic area with pyroclastic deposits, as well as, basaltic and andesitic lavas. These deposits create aquifers that store and transmit considerable volume of groundwater. The main aquifer unit is divided: North of Georgetown and South of Georgetown. The Project Area is located within the North of Georgetown aquifer unit, which geology is characterized by the historic eruption of La Soufrière Volcano, Late Pleistocene Fall deposits (Soufrière Volcano), and Pleistocene pyroclastic and lavas of La Soufrière Volcano. The North of Georgetown aquifer unit presents high and very high permeability (Murray 2014).

There are several springs flowing in the general Project Area from the main aquifer. These springs are formed at the contact between a less permeable lava horizon forming a local base, and the overlying permeable air fall deposits. Spring flows are constant throughout the year and low, with flows ranging between 1 cubic meter per hour (m^3/h) to 3 m^3/h. These characteristics indicate significant aquifer storage (Murray 2014 and Nippon Koei *et al.* 2015).

Table 4-8: Main Aquifers of the Project Area

Aquifer	Description
Main aquifer unit	Permeable pyroclastic deposits due to the significant layers of volcanic material that produce the sinking of rivers located within the Project Area; This ceases flow at low elevations produced by the rapid infiltration rate into the riverbed
Local aquifer unit	Agglomerates and coarse rock debris layering the borders of the volcanic centers; These agglomerates and coarse rock debris are likely to yield significant groundwater resources
Aquitard unit	A mixed assemblage of lavas and pyroclastic associated with the older volcanic centers; These are collectively considered to form limited and localized aquifers

Source: Adapted from Nippon Koei *et al.* 2015

The closest borehole to the Project Area is Overland borehole (see Figure 4-13), characterized by graded gravel and coarse sand material (from volcanic origin) from surface to a depth of approximately 23 m. This borehole has fragments of a consolidated lava flow (22 to- 24.5 m) and its porosity and permeability is extremely high. Table 4-9 provides more characteristics of the Overland borehole (Murray 2014).

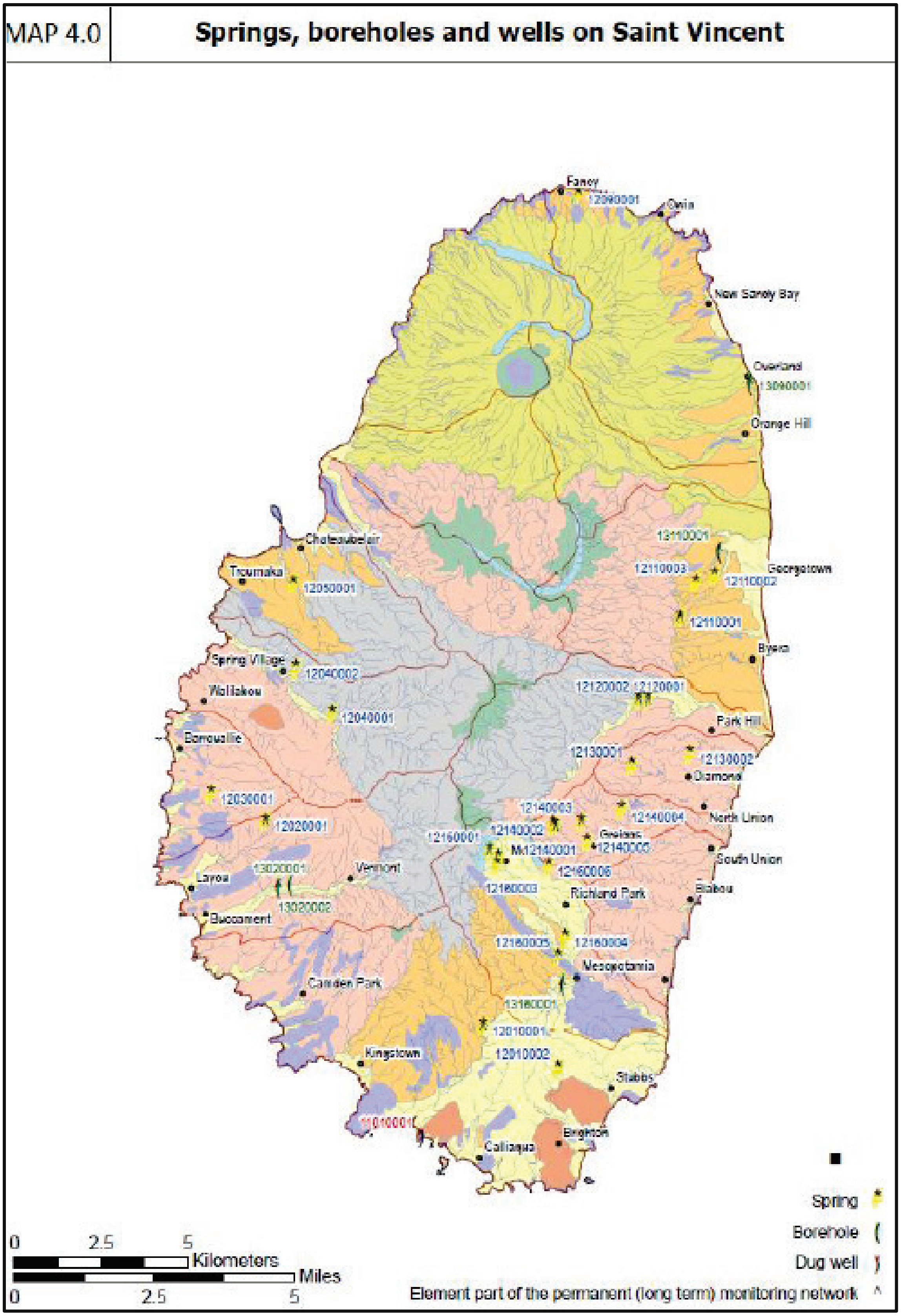
The Dixon borehole is located at the slope of the mountain east of Georgetown (see Figure 4-13). It is characterized by poor graded and heterogeneous loose alluviums and pyroclastic (silt and sand) for a depth of approximately 27.5 m from the surface. This borehole presents moderate permeability. Table 4-9 provides more characteristics of the Dixon borehole.

Table 4-9: Characteristics of Borehole

Borehole	Depth (m)	Water Level (m)	Water Yield (m^3/h)	Specific Capacity Yield of drawdown ($m^3/h/m$)
Overland	24.5	15.8	60-100	25
Dixon	27.5	12.4	---	---

m = meter; m^3/h = cubic meters per hour; $m^3/h/m$ = cubic meters per hour per meter

Source: Adapted from Murray 2014



Source: Murray 2014

Figure 4-13: Location of Boreholes and Wells on St. Vincent

4.1.6.4 *Water Quality*

There is no surface water quality information available from the rivers located within and close to the Project Area. However, as the river water comes mainly from rain/spring flow and only travels a short distance from river sources (maximum distance of 9.93 kilometers [km]) through an area with little human activity, the water quality can be considered good. However, the natural geology of the area can have effects on physical characteristics of surface water such as changes in ions and pH. During the site visit conducted in February 2016, the ERM team did not observe indicators of water pollution on the main rivers located within the Project Area: Rabacca River, Waribishy River, Camariabou River, and Tourama River. Figure 4-14 to Figure 4-16 show the existing conditions at different sections of the Rabacca River mainstream on February 2016 (dry season).

Figure 4-14: Rabacca River during Site Visit on February 2016

Figure 4-15: Rabacca River Upstream of Damaged Intake during Site Visit on February 2016

Figure 4-16: Mouth of the Rabacca River during Site Visit on February 2016

Table 4-10 presents results of available groundwater quality data measured on 29 August 2008 at the Overland borehole. These results indicate high concentrations of nitrites/nitrates, iron, and manganese. The natural geologic characteristics of the area (volcanic) contribute to the observed high levels of iron that are common to these types of area.

Table 4-10: Groundwater Quality near the Project Area

Borehole	**Conductivity (ug/cm)**	**pH**	**Hardness (mg/L)**	**Ca (mg/L)**	**Mg (mg/L)**	**Na (mg/L)**	**K(mg/L)**	**HCO3 (mg/L)**	**SO4 (mg/L)**	**Cl (mg/L)**	**Fe (mg/L)**	**Mn (mg/L)**	**NO3 (mg/L)**
Overland	229	8.1	112.9	71.2	7.0	17.0	2.9	93.9	9.16	16.3	3.121	0.122	3.3

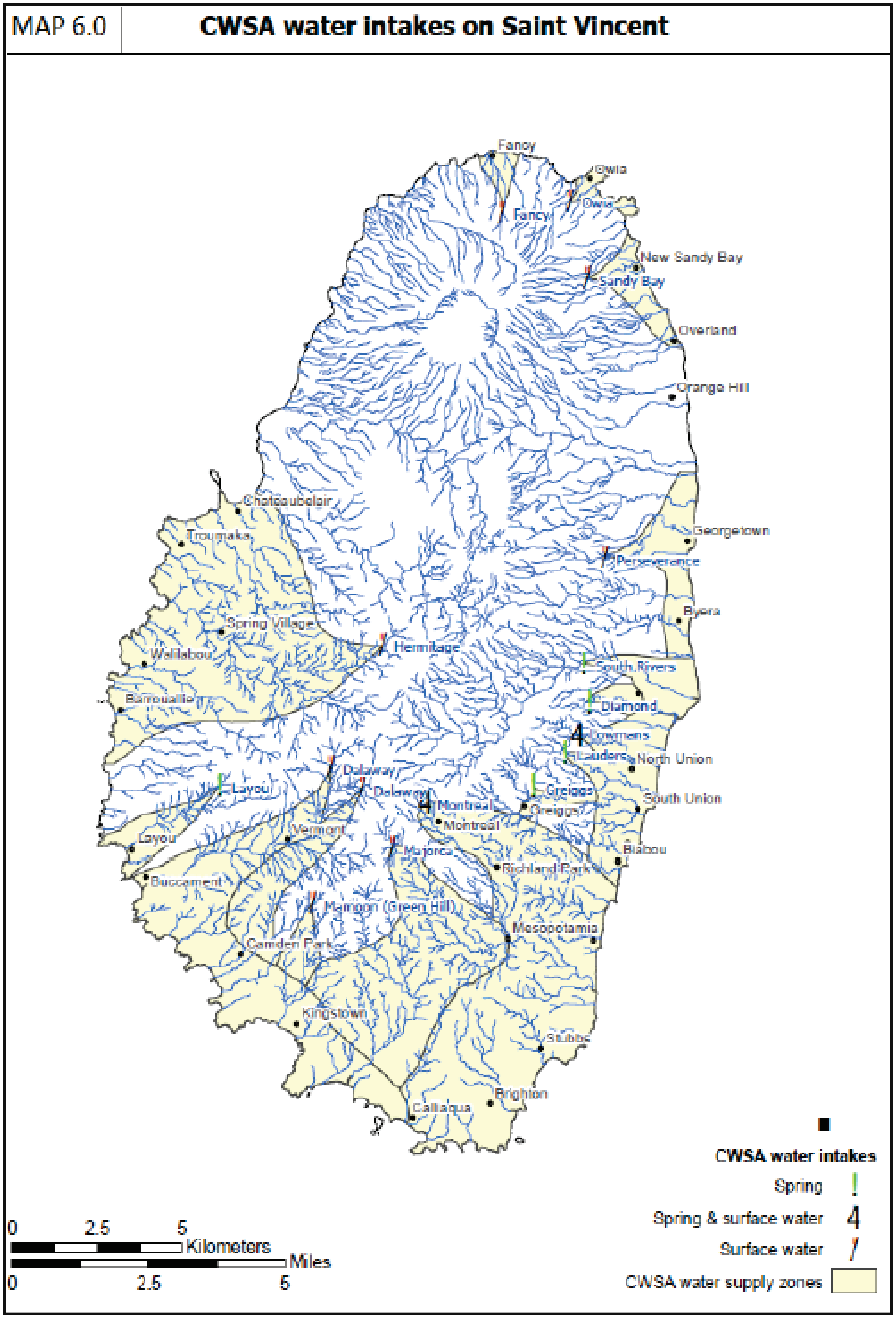
ug/cm = ; mg/L = milligram per liter

Source: Adapted from Nippon Koei *et al.* 2015

4.1.6.5 Water Uses

There are three hydropower projects totaling 5.6 megawatts (MW) on the island of St. Vincent; none are located in the Project Area watersheds (IDB 2015a). The CSWA uses water intakes and storage tanks around the island with a storage capacity of 19,836 m^3 (FAO 2016). According to CSWA (2013), the total water extraction accounted for SVG in 2013 was estimated as 8.5202 million m^3 (Mm^3). These total extractions were divided into 1.3 Mm^3 for municipal use that includes Government of SVG institutions, 0.7 Mm^3 for commercial uses, 5.4 Mm^3 for domestic uses, and 1.1 Mm^3 lost to leakages. Industry uses are approximately 0.002 Mm^3 per year. In 2013, there were no records for irrigation extractions in the Rabacca River as equipped areas had been abandoned after a large streamflow event damaged them (FAO 2016).

Murray (2014) reports that the CWSA has 100 percent coverage of potable water across the country, and approximately 96 percent of the population is connected to the potable water system (see Figure 4-17). Even though CWSA has a high percentage of potable connectivity, there are people who still use rivers for washing, bathing, or watering animals and plants without treatment. Interviews conducted during the site visit by ERM on February 2016 indicate that the local community only uses the Rabacca River for fishing crayfish and Sirajo goby, locally known as tri-tri, one or two times per year. In addition, communities are less reliant on the Rabacca River since they are connected to the water supply. However, it is unclear where water for pastoral land and animal rearing comes from. The CWSA water supply system uses surface water as its main source. However, SVG has experienced increases on drought, making CWSA consider the extraction of groundwater as a short-term alternative.



Source: Murray 2014

Figure 4-17: CWSA Water Intakes and Water Supply Zones

4.1.7 *Natural Hazards*

The dissected topography of SVG has increased its vulnerability to natural hazards such as landslides and flash flooding. SVG is located in an area exposed to hurricanes and volcanic activity. La Soufrière Volcano is a threat for SVG. The Monitoring Unit and Seismic Research Unit of SVG assess natural hazards including volcanic and seismic activity as well as mass landslides (Robertston 2003). The PreventionWeb (2016) reports human and economic losses in SVG are mainly associated with flashflood, flood, landslide, cyclone, hurricanes, and storm hazards (see Table 4-11).

Table 4-11: Percentages of Human and Economic Losses Associated with Natural Hazards in SVG

Hazard	Percent (%) Mortality	Percent (%) Combined economic losses
Cyclone	---	50.8
Flashflood	50.0	24.0
Flood	20.8	6.5
Landslide	29.2	7.1
Storm	---	8.2
Other	---	3.4

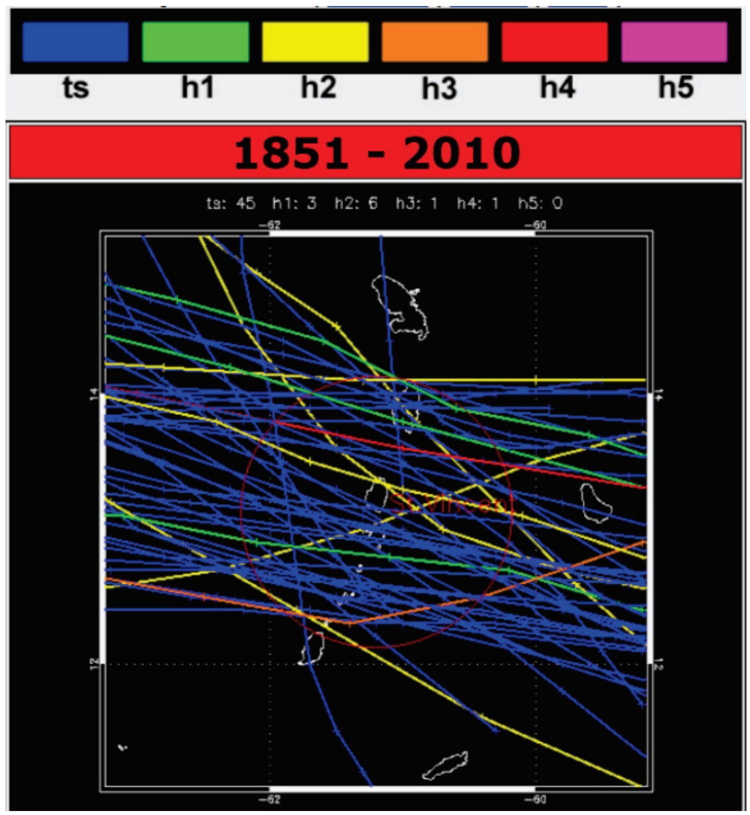
--- estimated as zero.

Source: Adapted from PreventionWeb 2016

Flash floods and their associated landslides and mudflow during tropical rainstorms have been identified as a concern in the coastal area between Orange Hill and Georgetown. According to Murray (2014) the north of St. Vincent is prone to landslides, particularly around La Soufrière Volcano. This area is considered extremely high risk for landslides and presents frequent and easy large-scale erosion during intense precipitation storm due to its uncompact nature of volcanic material.

There are three hurricane tracks in the Caribbean, and SVG is located within the Eastern Caribbean track (Caribbean Hurricane Network 2011). The Eastern Caribbean track includes the Lesser Antilles. Approximately 11 hurricanes and several tropical storms have crossed SVG from 1851 to 2010 (see Figure 4-18). Hurricane Allen, a category h4 (extreme) hurricane, passed just north of SVG with 130 miles per hour (mph) winds from east to southeast on 4 August 1980 while Hurricane Tomas, a category h2 (moderate) hurricane, passed just north of SVG with 80 mph winds on 30 to 31 October 2010. Hurricane Thomas heavily affected SVG's socio-economic development with floods, landslides, and sea surge. Hurricane Thomas also caused damages to schools and community centers that are part of the national network of emergency shelters (World Bank 2016).

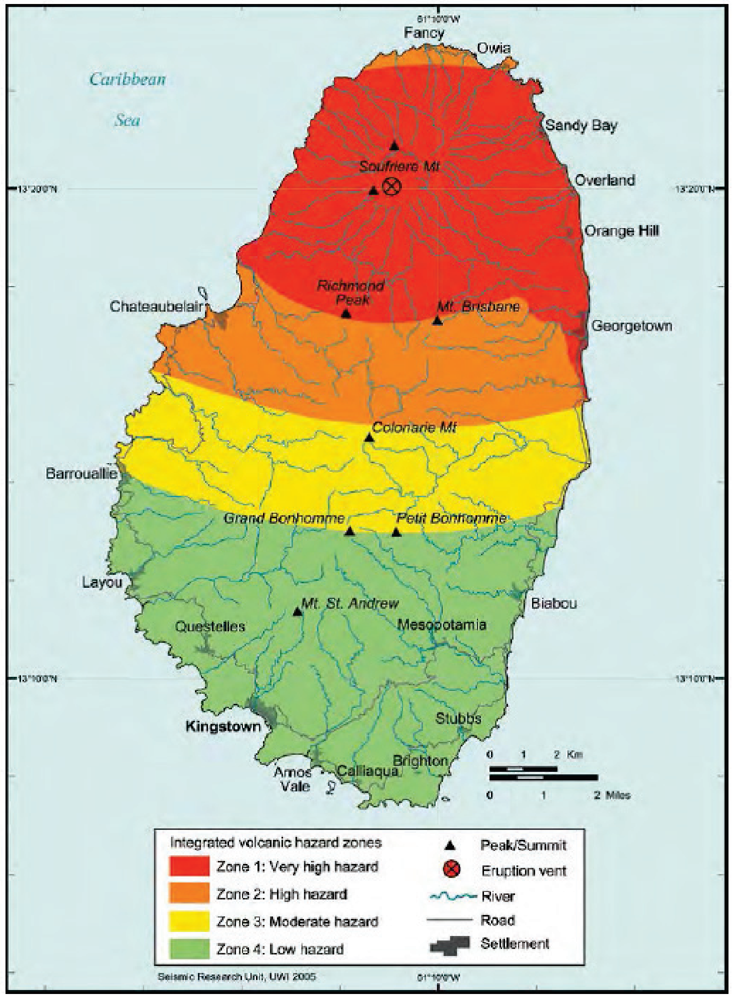
The Project Area is located around the La Soufrière Volcano, which is an active volcano. La Soufrière Volcano's crater (1.6 km wide) and dome form the northern quarter of St. Vincent. Since 1718, La Soufrière Volcano has erupted five times (1718, 1812, 1902, 1971, and 1979). The 1812 eruption caused 80 fatalities while the 1902 caused approximately 1,600 deaths. The most recent eruption in 1979 did not cause any fatalities because warning systems were used and approximately 20,000 people were evacuated on time from the north part of St. Vincent. All eruptions from La Soufrière Volcano have damaged properties and farmland, including the area where the Project would be located.



Source: StormCARIB 2011

Figure 4-18: Hurricanes and Tropical Storms affecting SVG (1851-2010)

Figure 4-19 shows the integrated volcanic hazard zones, indicating that the Project Area is located within Zone 1 (very high volcanic hazard). This very high volcanic hazards classification is designated due to La Soufrière Volcano, an active volcano. Based on historical eruption activities and studies conducted by the Soufrière Monitoring Unit and Seismic Research Unit (Robertson 2003), La Soufrière Volcano is a constant threat for SVG. SVGCL indicated that the Project area is within the defined volcano hazard zone, but located between the possible lahar flow paths.



Source: Nippon Koei *et al.* 2015

Figure 4-19: Volcanic Risk Zones in St. Vincent

Even though the Eastern Caribbean area is seismically active with approximately hundreds of earthquakes per year, St. Vincent has not been an epicenter of any recent significant earthquakes. On November 2007, an earthquake (7.3 on the Richter scale) hit St. Vincent, causing significant damage. The most recent significant earthquake occurred on 16 July 2015 (6.5 on the Richter scale) with an epicenter located off the Barbados coast.

4.2 *BIODIVERSITY BASELINE*

This biodiversity baseline provides an overview of the terrestrial and freshwater aquatic biodiversity of the Project Area. The baseline includes a description of the biological setting, a summary of the biodiversity baseline survey approach, and a description of the terrestrial and aquatic ecosystems, flora, fauna, and rare and/or endemic species present in the Project Area (i.e., 2 km^2 square area where the main Project components would be located, see Chapter 3.0, *Description of the Proposed Project*).

4.2.1 *Biological Setting*

4.2.1.1 Biogeographic Setting

The Project Area setting is dominated by La Soufrière Volcano, SVG's youngest volcano, which encompasses much of the northern quarter of the island and part of the northwest coast. The Project Area lies on the eastern (windward) side of the volcano, approximately one third of the way up the slopes of the volcano at elevations between 172 and 448 meters above sea level (masl) (USGS 2006) (see Figure 4-20). La Soufrière is an active volcano. Eruptions have resulted in a unique successional ecosystem with a mixture of secondary rainforest and volcanic pioneer vegetation. Various tributaries and waterfalls emanate from the volcano's steep slopes, while the foothills support some agriculture (particularly banana cultivation) and, at lower elevations, several forest plantations established by the Forestry Department of SVG. High rainfall, along with loose volcanic deposits, makes the area vulnerable to erosion and landslides. La Soufrière Volcano is one of the major watersheds in north St. Vincent and one of the identified Important Bird Areas (IBA) in the country.

Figure 4-20: Biogeographic Setting

4.2.1.2 *Protected Areas*

In October 2009 the SVG National Parks, Rivers, and Beaches Authority (NPRBA) developed the *National Parks and Protected Areas System Plan of 2009-2014* (*Plan*). The Plan was developed in response to the economic decline in the banana industry and as a way to fill the void in the national economy by strategically targeting growth within the tourism sector. The Plan focuses on developing community-based tourism at several specific locations within SVG, encompassing areas with significant biodiversity, rich cultural and historical heritage, and recreational potential since SVG already attracted tourists interested in having the "Caribbean Experience." The Plan is undergoing implementation but has not been fully implemented due to funding and other resourcing constraints (SVG NPRBA, 2016). To date, the Government of SVG has established 35 protected areas, and there are 75 additional sites proposed for protection.

Five existing or proposed protected areas lie in the immediate vicinity of the Project area (Figure 4-21):

- The proposed La Soufrière National Park borders the Project area to the west and northwest;
- The existing Mount Pleasant Forest Reserve borders the Project area to the southwest;
- The existing St. Vincent Parrot Reserve straddles the central mountain range in St. Vincent roughly 2 km southwest of the Project area;
- The proposed Youroumei Heritage Village Cultural Landmark lies 1.4 km east of the Project area; and
- The proposed Rabacca River Recreational Park lies 2.6 km east of the Project area.

Of these, the National Park, Mount Pleasant Forest Reserve, and the St. Vincent Parrot Reserve were designated for or contain biodiversity resources. The other two sites were proposed for their cultural heritage or recreational values and are therefore not discussed further here.

4.2.1.2.1 *La Soufrière National Park*

The proposed La Soufrière National Park encompasses much of the northern quarter of the island, including part of the northwest coast (Figure 4-21). La Soufrière is an active volcano and one of the country's main tourist attractions. It has a long history of eruptions with the historical records showing eruptions in 1718, 1812, 1902, 1971and 1979 (see Section 4.1.7, *Natural Hazards*). As a result of the volcanic eruptions, the surrounding area supports a unique successional ecosystem with a mixture of secondary rainforest and volcanic pioneer vegetation. Various tributaries and waterfalls emanate from the steep slopes, while the foothills support some agriculture (particularly banana cultivation) and, at lower elevations, several forest plantations established by the SVG Forestry Department. High rainfall, along with loose volcanic deposits makes the area vulnerable to erosion and landslides. La Soufrière is one of the major watersheds in north of St. Vincent and one of the identified IBA in the country.

4.2.1.2.2 St. Vincent Parrot Reserve

The St. Vincent Parrot Reserve was established under the Wildlife Protection Act to provide protection for the St. Vincent Parrot (*Amazona guildingii*), the SVG national bird. The Reserve encompasses all or portions of the following forest reserves (Figure 4-21):

- Colonarie Forest Reserve
- Cumberland Forest Reserve
- Dalaway Forest Reserve
- Kingstown Forest Reserve
- Mt. Pleasant Forest Reserve
- Richmond Forest Reserve
- La Soufrière National Park

The boundary of the reserve encompasses all known occupied breeding habitat for the species.

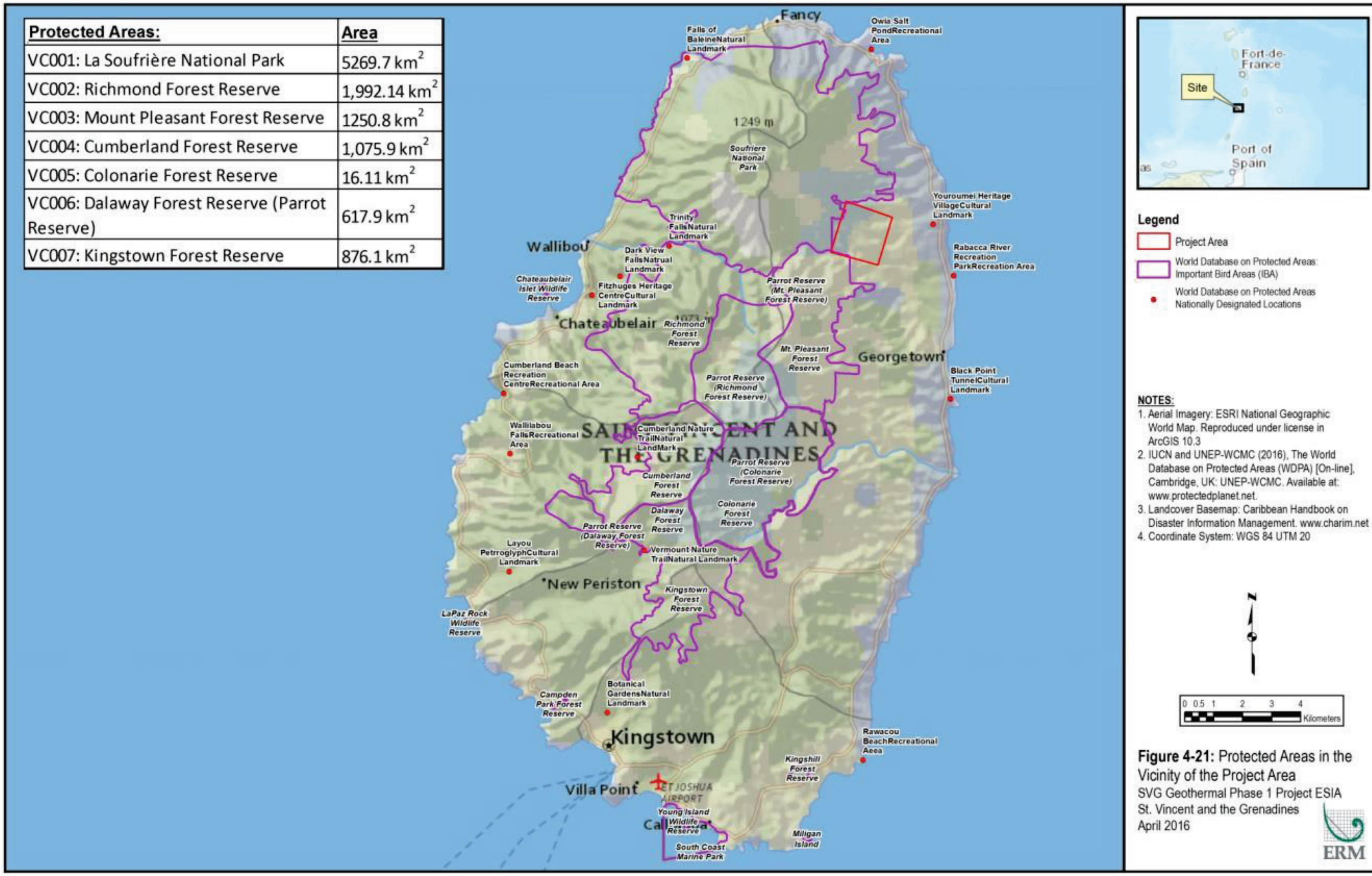


Figure 4-21: Protected Areas in the Vicinity of the Project Area

4.2.2 *Baseline Survey Approach*

4.2.2.1 *Survey Objectives*

The objectives of the survey were as follows:

- Document vegetation communities and habitat conditions (level of naturalness and anthropogenic disturbance) at the exploration drill pads and injection pads and their surrounding areas;
- Determine the known use and potential use by locally or globally rare and endemic species;
- Determine the level of importance of the Project Area to rare and endemic species;
- Assess the level of uniqueness/conservation importance of the Project Area at local and national scales; and
- Document through interviews with local people traditional and local knowledge and use of the Project Area and vicinity (e.g., traditional medicine practices and other traditional/local uses of wildlife and flora; location and extent of culturally important habitats; location of hunting, fishing, and gathering areas; and wildlife population and habitat trends).

4.2.2.2 *Biodiversity Study Area*

The study area for the biodiversity assessment, corresponding to the Project Area, included the following, (see Figure 4-22):

- Exploration Drill Pads W1 and W3 and surrounding areas;
- Injection Pads W1 and W3 and surrounding areas (important to note the locations of these pads is approximate); and
- The Rabacca River upstream and downstream of the potential water abstraction location.

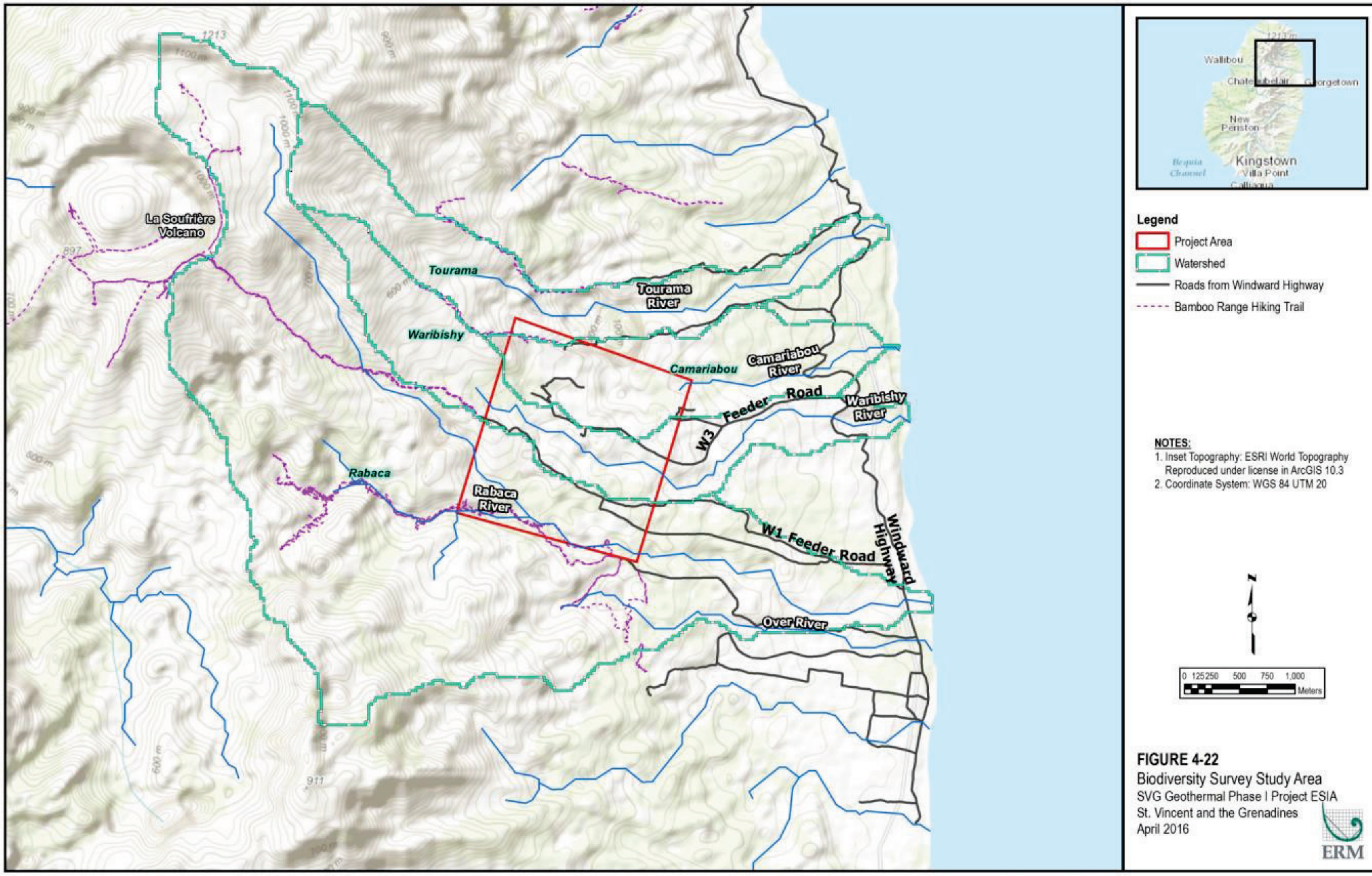


Figure 4-22: Biodiversity Survey Study Area

4.2.2.3 *Survey Approach*

ERM conducted a baseline biodiversity field survey from 22 February through 26 February 2016. SVG biodiversity specialists also participated in this survey, including the following individuals:

- Mr. Glenroy Gaymes – biodiversity survey lead, terrestrial and freshwater aquatic biodiversity
- Dr. Joanne Mae Justo-Gaymes – terrestrial biodiversity and herpetofauna
- Ms. Lystra Culzac – terrestrial biodiversity, with focus on birds

The survey was undertaken following a Rapid Assessment Program approach, consisting of the following steps:

- Desktop review of publicly available biodiversity data for historic and current ecosystems, habitats, and species;
- Assessment of publicly available satellite imagery and Geographic Information System data for the biodiversity study area and vicinity to assess the state of habitat conditions; and
- Field survey, aimed at rapid inventory of the terrestrial and freshwater aquatic flora and fauna species present or potentially present in the biodiversity study area, with particular focus on rare and/or endemic species or other species of conservation interest (e.g., undescribed species).

The terrestrial field survey methods included a walkover of each Project component location, focused primarily on the exploration drill pad sites and their surrounding areas but covering all Project elements, to generally characterize the habitat conditions and vegetation communities present. The team conducted walking transects, recording species seen and heard along the transect, point counts for birds, and active searches of suitable habitats (woody debris, rock piles, vegetation) for reptiles and insects. The team collected a detailed photographic log of the biodiversity study area and its biodiversity elements and recorded locations of any rare or endemic species observed on hard copy maps and with a Global Positioning System. Surveys covered early morning through early evening (generally between the hours of 06:00 and 18:00), with different survey activities conducted at appropriate times of the day when target species and taxa were most active.

The aquatic survey methods involved general aquatic habitat characterization of the Rabacca River and its tributaries and basket sampling for fish and invertebrates, with a focus on documenting habitat conditions for and presence of Sirajo goby (*Sicydium plumieri*) and any other species of conservation, economic, or cultural importance.

4.2.3 *Terrestrial Biodiversity Survey Results*

4.2.3.1 *Overview of Current Terrestrial Biological Conditions in the Biodiversity Study Area*

The biodiversity study area contains a mix of small food crop agriculture, pasture, and regenerating grasslands, shrublands, and forest, with some remnant forests interspersed throughout, particularly on steep hill slopes and ridges. The forested ridges surrounding the pad sites have remained relatively undisturbed by human activity and exhibit high biological integrity. Both exploration pad sites are bordered by steep valleys or hill slopes that contain emerging transition secondary forest. Slightly higher in elevation up the volcano from the Project Area, rainforest becomes the dominant ecosystem and much of this forest remains intact.

(Photograph Taken Along the Access Road to Exploration Drill Pad W1)

Figure 4-23: Typical Farm Plot Surrounded by Natural and Plantation Forest

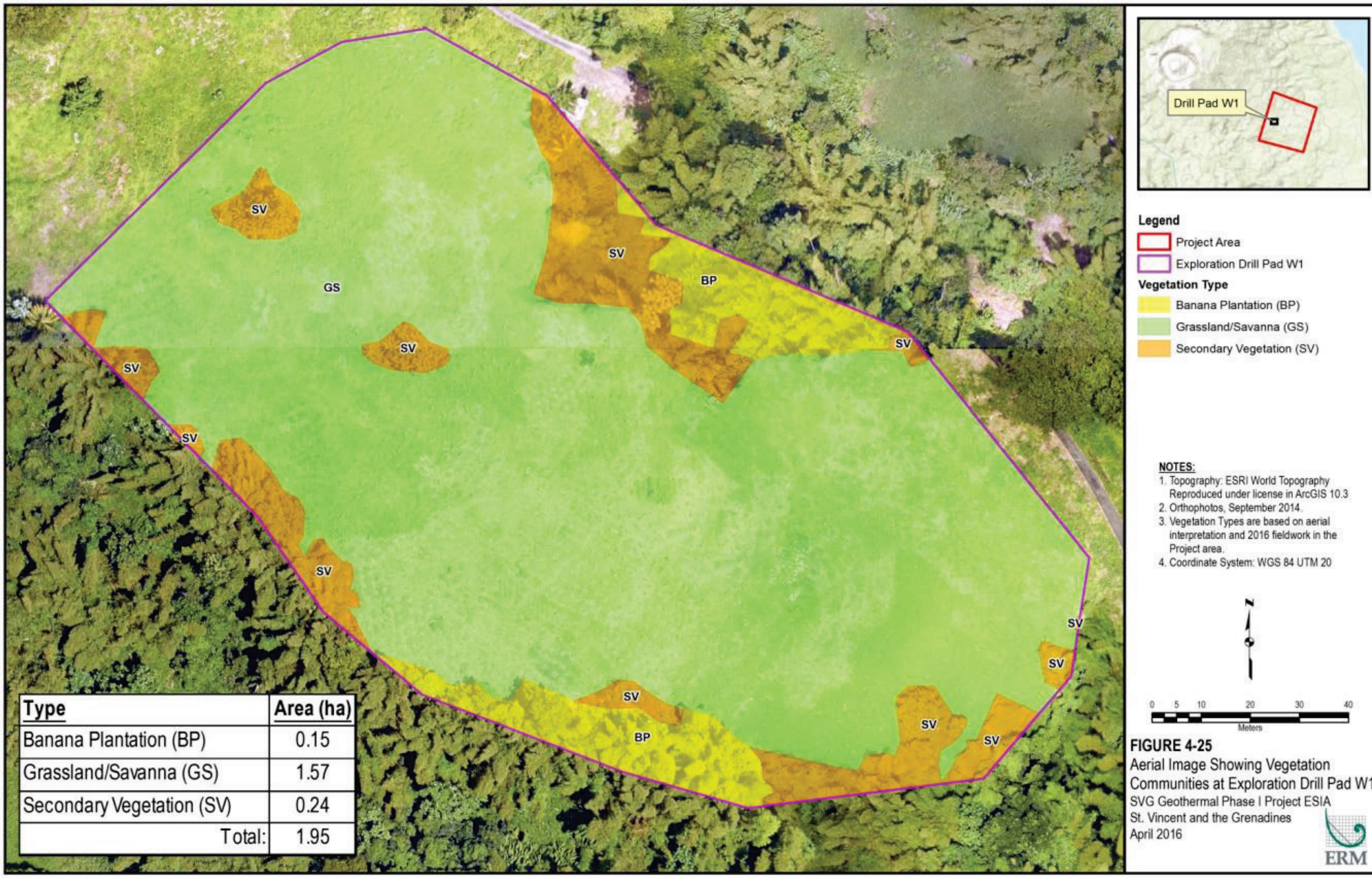
(Photograph Taken from Bamboo Range near Exploration Drill Pad W1)

Figure 4-24: Representative Forest on La Soufrière Volcano Terrestrial Biodiversity Survey Results

Appendix B and C provide the complete lists of vegetation and fauna species documented in the biodiversity study area. The following sections provide a general description of the vegetation communities and the fauna observed in the biodiversity study area.

4.2.3.1.1 Exploration Drill Pad W1

Exploration Drill Pad W1 lies approximately 500 m from Bamboo Range, a tourism embarkation point for the windward La Soufrière trail (Figure 4-22). The site lies within an existing banana plantation, which occupies over 80 percent of the site (Figure 4-25). The remainder of the site consists of regenerating secondary forest in the valley on the west side of the site and patches of shrublands along the perimeter of the site. A mahogany plantation lies to the west of the site. The survey documented 63 plant species on this site (see Appendix B, *Vegetation Species*), the highest diversity of which occur along the margins of the site that are not cultivated with banana. The dominant plant species on this site is banana while mahogany, Spanish ash, and bamboo are dominant along the periphery.



Type	Area (ha)
Banana Plantation (BP)	0.15
Grassland/Savanna (GS)	1.57
Secondary Vegetation (SV)	0.24
Total:	1.95

Figure 4-25: Aerial Image Showing Vegetation Communities at Exploration Drill Pad W1

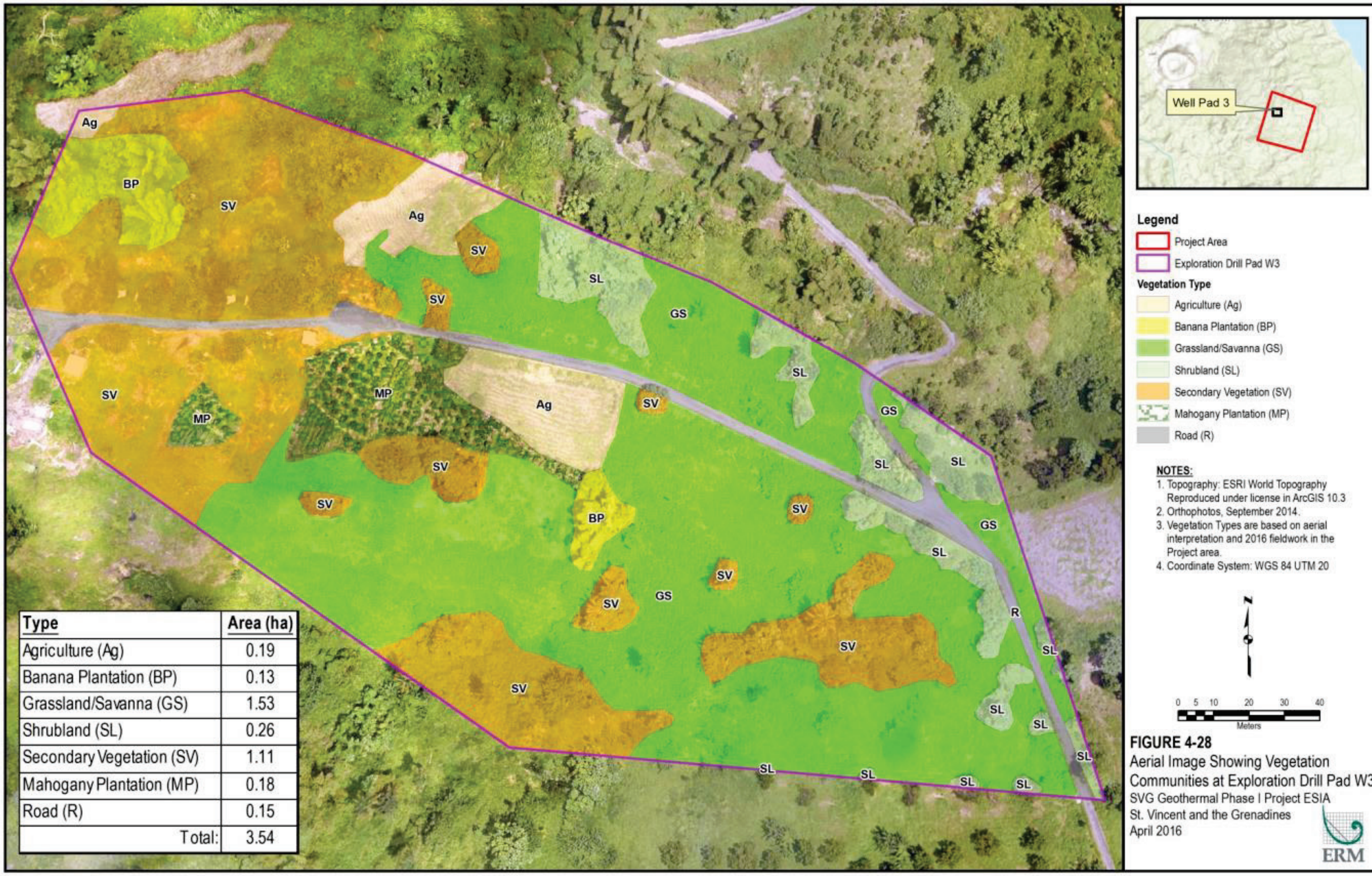
Figure 4-26: Exploration Drill Pad W1 – Banana Trees and Surrounding Bare Ground with Limited Herbaceous Vegetation

Figure 4-27: Exploration Drill Pad W1 – Dense Banana Cultivation Surrounded by Regenerating Secondary Forest

Surveys documented 71 terrestrial wildlife species at the site. These numbers do not include mosquito and fly species, which though present were not a focus of this study. The invertebrate taxa group exhibited the highest species richness, with 45 different species recorded, followed by birds (n=18), reptiles (n=4), mammals (n=3) and amphibians (n=1). Few species were recorded on the actively-farmed banana *Musa* sp. plantation, and those that were documented primarily consisted of invertebrates within the leaf litter. These included ants, spiders, roaches, millipedes, and ground lizards that sheltered under the fallen, dried banana foliage. A greater diversity of species was observed within fallow areas and regenerating secondary rainforest compared with the plantation.

4.2.3.1.2 Exploration Drill Pad W3

Exploration Drill Pad W3 is an abandoned cultivated area. Regenerating herbaceous vegetation and shrubland dominates the vegetation at this site, and some portions of the site are used as pasture for sheep and pigs. Remnant citrus trees and other fruit crops occur throughout the site. The site is surrounded by patches of fragmented secondary forest (see Figure 4-28). The survey documented 89 plant species at this site (Appendix B, *Vegetation Species*). The dominant plant species on this site include rabbit feed *(Emilia fosbergii* and *Vernonia cinerea*) and ram goat bush *(Aegephila matinicensis)*.



Type	Area (ha)
Agriculture (Ag)	0.19
Banana Plantation (BP)	0.13
Grassland/Savanna (GS)	1.53
Shrubland (SL)	0.26
Secondary Vegetation (SV)	1.11
Mahogany Plantation (MP)	0.18
Road (R)	0.15
Total:	3.54

Figure 4-28: Aerial Image Showing Vegetation Communities at Exploration Drill Pad W3

Figure 4-29: Exploration Drill Pad W3 – Mix of Fallow Agriculture, Regenerating Native Vegetation, and Remnant Forest

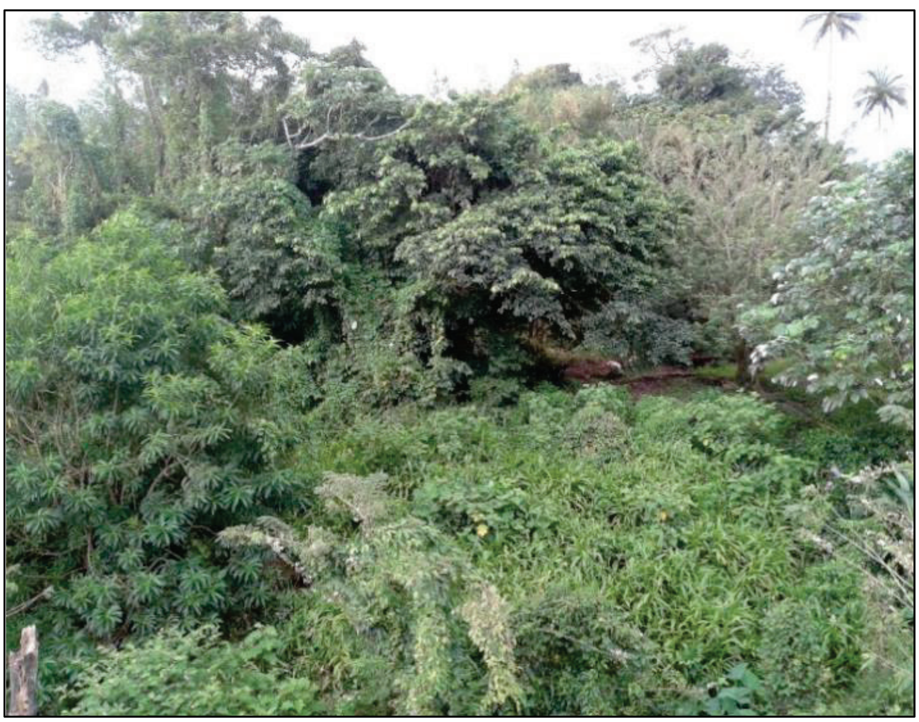


Figure 4-30: Exploration Drill Pad W3 - Pioneer Species Emerging to Secondary Forest Along the Edge of the Site

Surveys documented 86 terrestrial wildlife species at the site. The highest species richness occurred within the invertebrate group (n=58), followed by birds (n=20), reptiles (n=4), mammals (n=2), and amphibians (n=2).

4.2.3.1.3 Injection Pad W1

The site contains fallow farmlands with patches of recent agricultural intervention. The site lies adjacent to a Blue Mahoe *Hibiscus elatus* plantation, which also contains a mix of secondary forest regeneration (see Figure 4-32).

Figure 4-31: Injection Pad W1- Fallow Agriculture with Forest Border (Just Offsite)

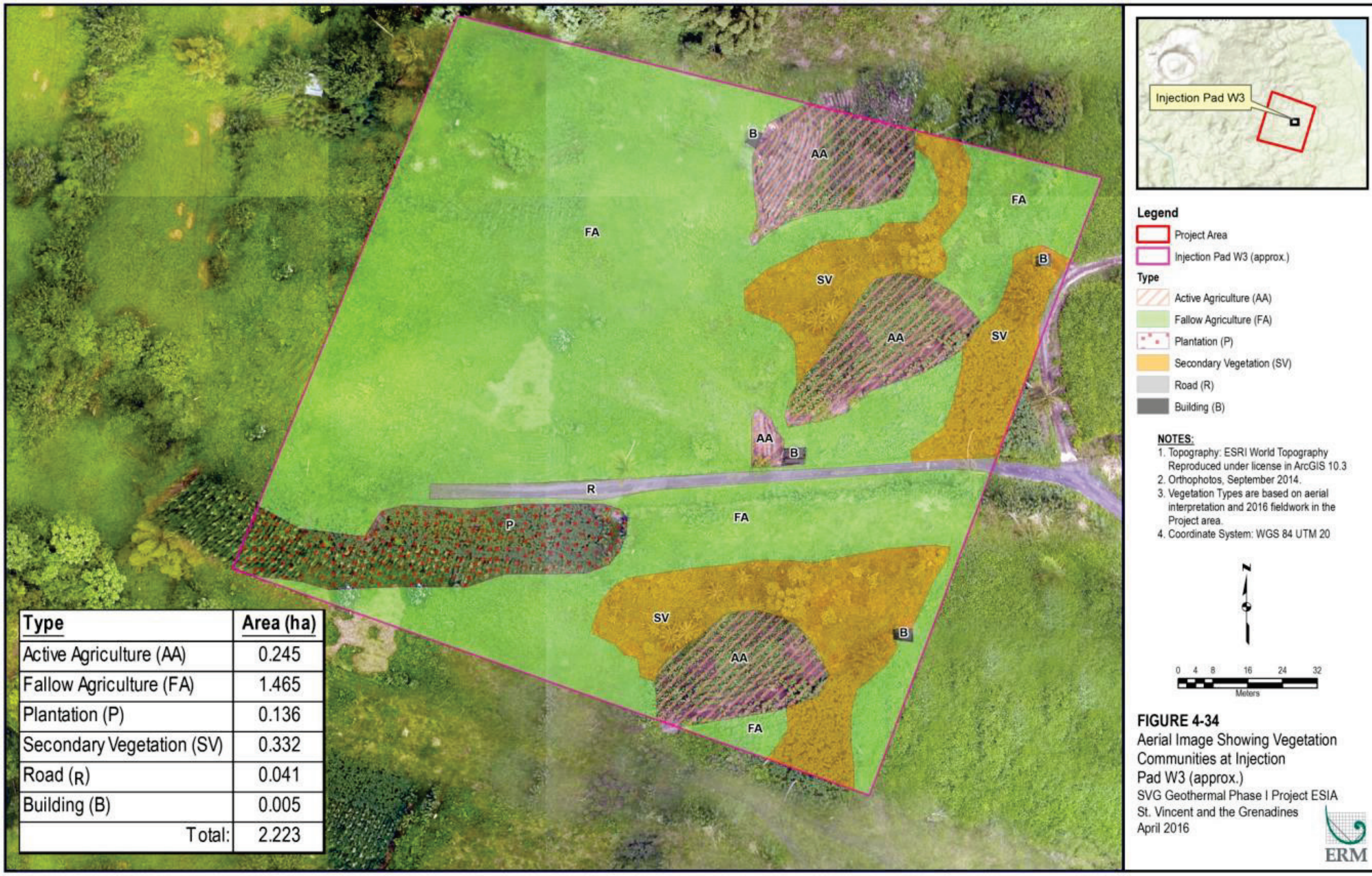
Type	Area (ha)
Active Agriculture (AA)	0.086
Fallow Agriculture (FA)	0.911
Grassland/Savanna (GS)	0.270
Plantation (P)	0.309
Secondary Vegetation (SV)	0.351
Road (R)	0.027
Building (B)	0.002
Total:	1.957

Figure 4-32: Aerial Image Showing Vegetation Communities at Injection Pad W1

4.2.3.1.4 Injection Pad W3

The site area is actively used for agriculture with cabbage, tomato, and christophene as the major crops (see Figure 4-34).

Figure 4-33: Injection Pad W3 – Mix of Active and Fallow Agriculture with Scattered Trees



Type	Area (ha)
Active Agriculture (AA)	0.245
Fallow Agriculture (FA)	1.465
Plantation (P)	0.136
Secondary Vegetation (SV)	0.332
Road (R)	0.041
Building (B)	0.005
Total:	2.223

Figure 4-34: Aerial Showing Vegetation Communities at Injection Pad W3

4.2.3.2 *Freshwater Aquatic Biodiversity*

Habitat conditions observed during the field survey indicate that flows in the Rabacca River are highly variable and the substrate in the river is subject to frequent scour and sedimentation events during high flows. Despite the presence of a substantial vegetated riparian buffer along much of the river consisting of tree ferns *Cyathea tenera*, various grasses (*Roseau* sp.), and pioneer tree species such as burn lime (*Sapium caribaem*), Spanish ash (*Inga ingoides*), trumpet tree (*Cecropia peltata*), and balsa (*Ochroma pyramidale*), the riverbanks are actively eroding in many places. Bare soil and undercut banks along densely vegetated riverbanks together with the abundant alluvial deposits intermixed with larger substrate (i.e., cobbles and boulders) provide ample evidence of the erosive power of high flows and the unstable character of the riverbed.

Historically, river flow in the lower Rabacca River is discontinuous in the dry season as the river infiltrates through the sandy riverbed and flows underground in some areas. Nevertheless, the presence of a migratory fish and several amphidromous shrimps in the river indicates that seasonal surface continuity with the marine environment is an important aspect of the ecology of the upper Rabacca River.

Figure 4-35: Rabacca River Downstream View

Figure 4-36: Tributary to the Rabacca River

4.2.3.3 *Fish and Invertebrates*

The Caribbean islands typically possess relatively low levels of freshwater biodiversity. Several factors contribute to this, including the small size and young geologic age of the islands, volcanic activity that can cause localized extinctions, and the relative isolation of freshwater systems on islands surrounded by ocean (Bass 2003; Neal *et al*. 2009). On many islands, a small number of "peripheral" freshwater species that migrate between freshwater and marine environments constitute the bulk of the freshwater biological community (Bass, 2003; Neal *et al.* 2009).

There have been no previous studies of the freshwater biodiversity of the Rabacca River prior to this assessment. Substantial rainfall the day prior to the field survey increased streamflow in the Rabacca River, but the river exhibited relatively low turbidity during the survey. This observation indicates that water quality probably recovers quickly in the Rabacca River after a rain event and that most of the fine sediment present in the river derives from the streambanks themselves rather than further upslope in the catchment. Such aquatic habitat conditions favor mobile habitat generalists that can move to microhabitats out of the main channel flow during high flow periods and back to main channel during low flow. It also favors large-bodied macroinvertebrates and fish that are not dependent on intergranular microhabitats between or under coarse substrates because these microhabitats are vulnerable to rapid infill by fine sediment during high flows.

This study documented two species of fish in the Rabacca River including the Sirajo goby (*Sycidium plumieri*), juveniles of which are locally known as tri-tri, and a species locally-known as suck stone (*Gobiesox s*p.). The study also documented five species of crustaceans including river lobster (*Macrobrachium carcinus*), gundy man (*Macrobrachium crenulatum*), crayfish (*Macrobachium faustinum*), crayfish (*Macrobachium heterchirus*), and booky man (*Atya innocuous*). The shrimps in the study area are all migratory: adults spawn in freshwaters and the hatched larvae drift downstream to saltwater where they develop into juveniles. The juveniles then migrate back upstream where they spend their entire adult lives (Snyder *et al*. 2011).

Of the species documented, the primary species of interest is the Sirajo goby because it is fished locally and is a migratory species (see Figure 4-37). The Sirajo goby is a freshwater species with an estuarine larval stage. Adults spawn in freshwater and eggs are laid on hard substrates such as rocks or logs, usually in deep pools. Once hatched, the larvae migrate downstream to the ocean to grow for approximately 1 to 2 months and then the juveniles migrate back to freshwater to continue growth. Once fully mature, they spawn several times. The full spawning range within the river has not been fully documented but it is thought to be broad and encompass most of the freshwater portion of the river almost up to its headwaters. As such, the study area lies roughly in the middle of the spawning range of the species in the Rabacca River.

The species' range is relatively broad in the Caribbean region and encompasses most of the Caribbean Antilles south of Puerto Rico including Barbados, Cuba, Dominica, Guadeloupe, Jamaica, Martinique, Puerto Rico, SVG, Trinidad and Tobago, and the United States (US) Virgin Islands (Froese and Pauly 2016). On St. Vincent, the species occurs in the Rabacca, Richmond, Cumberland, and Colonarie rivers. The species is relatively common in St. Vincent, and juveniles are heavily fished when they migrate upstream in large numbers.

Figure 4-37: Sirajo goby *Sycidium plumieri* captured from the Rabacca River

4.2.3.4 *Rare and Endemic Species*

For the purposes of this assessment, rare species are defined as those that are: 1) listed as Near Threatened (NT), Vulnerable (VU), Endangered (EN), or Critically Endangered (CR) on the International Union for the Conservation of Nature (IUCN) Red List Version 2015.4 (IUCN 2016); or 2) endemic and range-restricted species, including but not limited to those included on the list of Species of National Concern in SVG.

4.2.3.5 *IUCN Red-List and Nationally Listed Species*

The IUCN Red List of Threatened Species Version 2015.4 (IUCN 2016) uses a set of criteria relevant to all species and regions throughout the world to categorize species according to their risk of global extinction. The categories range from Extinct to Least Concern (Table 4-12). Collectively, species categorized as CR, EN, and VU are considered to be internationally "threatened".

There are two species on the IUCN Red List that are known to occur in or near the biodiversity study area: St. Vincent Parrot (*Amazona guildingii*, listed as VU) and St. Vincent Whistling Frog (*Pristimantis shrevei*, listed and EN). The following paragraphs and Table 4-13 summarize key information regarding these species.

Table 4-12: Definitions of IUCN Red List Threatened Categories

IUCN Red List Status	Definition
Critically Endangered (CR)	A taxon is Critically Endangered when the best available evidence (severe population decline, very small population, very small geographic area occupied, or a probability of extinction in the next 10 years of >50%) indicates that it is facing an extremely high risk of extinction in the wild.
Endangered (EN)	A taxon is Endangered when the best available evidence (large population decline, small population, small geographic area occupied, or a probability of extinction in the next 20 years of >20%) indicates that it is facing a very high risk of extinction in the wild.
Vulnerable (VU)	A taxon is Vulnerable when the best available evidence (substantial population decline, small population, fairly small geographic area occupied, or a probability of extinction in the next 100 years is >10%) indicates that it is considered to be facing a high risk of extinction in the wild.
Near Threatened (NT)	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered, or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

% = percent; IUCN = International Union for the Conservation of Nature

Source: IUCN 2001

4.2.3.5.1 St. Vincent Parrot

The St. Vincent Parrot is St. Vincent's sovereign bird (see Figure 4-38). IUCN listed it as Vulnerable because of its small population, limited range that is restricted to only one island, and threats including habitat loss (deforestation) and collection for trade (BirdLife International 2013). It is the only parrot found on St. Vincent. The parrot has two morphs, the commonly found yellow-brown variant and the less common green-feathered variant. The species generally inhabits moist forests between elevations of 125 to 1,000 masl but prefers mature growth forests at lower elevations within the western and eastern ridges of St. Vincent (BirdLife International 2013). Individuals feed on a variety of fruits, seeds, and flowers within the forest canopy. Individuals also frequent plantations and other agricultural areas where individuals forage on fruit and other agricultural crops. Nests typically occur within the cavities of large, mature trees. Individuals breed between January and June, with peak breeding occurring from February through May (Kirwan 2010). Nests often occur in loose aggregations of approximately 12 individuals, each defending its own nest site but tolerating the close proximity of nearby pairs. During wetter years, birds may not attempt to breed.

The population is currently estimated at roughly 800 individuals, with numbers steadily, although slowly, increasing (BirdLife International 2013). A comprehensive species conservation plan was published in 2005 (Snyder *et al.* 2005). This plan attributes the species' recovery to increased law enforcement, implementation of effective public awareness campaigns, and protection of the species' breeding habitat within the St. Vincent Parrot Reserve and lists several long-term conservation actions designed to enhance recovery of the species.

Under the 1987 *Wildlife Protection Act* (No. 16), the SVG Forestry Department established a captive breeding population. The captive breeding program for the species is one of the most successful parrot breeding programs in the world and there are active captive breeding programs for the species on St. Vincent, Barbados, Germany, and the US.

The study area lacks breeding habitat for St. Vincent parrots; however, the field survey conducted for this assessment documented numerous individuals of both color morphs flying over the study area, and numerous individuals were also seen and heard in the forests immediately surrounding Exploration Drill Pad Sites W1 and W3. The study area lies within a well-known movement corridor for the species.

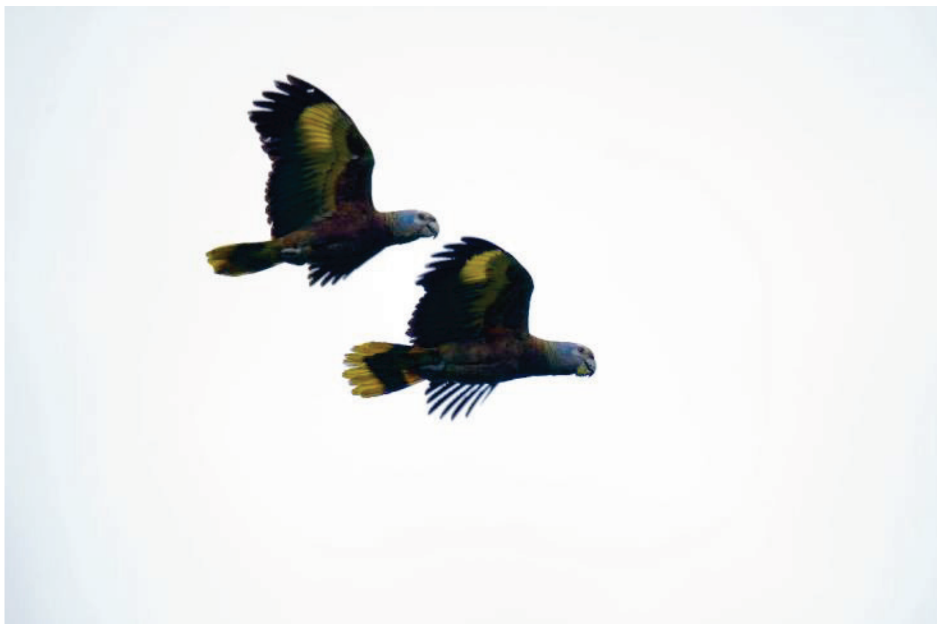


Figure 4-38: St. Vincent Parrot *Amazonia guildingii*

4.2.3.5.2 St. Vincent Whistling Frog

The St. Vincent whistling frog (see Figure 4-39) is listed by IUCN as EN due to its extremely low population size, limited range, habitat loss. It is restricted to the interior, mountainous region of St. Vincent from roughly 300 to 980 masl (Hedges 2004). The frog is an arboreal species (spends most of its life on trees) that is found in a variety of habitats, including rainforests, forest edges, and montane forests and meadows surrounded by agriculture (Hedges 2004). Like other frog species, eggs are laid on the ground and/or are attached to detritus and breeding occurs by direct development. The population status is decreasing (Government of SVG Forestry Department 2016).

The field survey conducted for this assessment documented one St. Vincent whistling frog at the emerging secondary forest along the periphery of exploration drill pad W1. The species is not known to occur in agricultural habitats, but this finding was not unexpected because of the proximity of the site to the species preferred habitat.

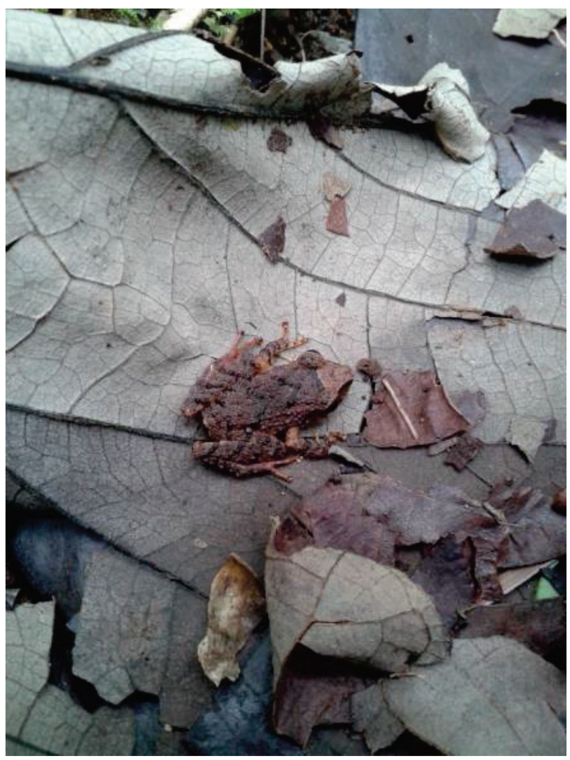


Figure 4-39: St. Vincent Whistling Frog (*Pristimantis shrevei*) at Exploration Drill Pad W1

4.2.3.6 *Endemic and Restricted-range Species*

The list of Species of National Concern in SVG includes those species that are endemic to SVG (referred to as local endemics) or the Caribbean Lesser Antilles (referred to as regional endemics) and includes 44 species, including 21 plants, 6 birds, 3 mammals, 11 reptiles, 1 amphibian, and 3 invertebrates. Although not included on the National list, there are 5 additional species (all birds) that are considered range-restricted species that have a broader range than the Caribbean Lesser Antilles but are still restricted to the Caribbean region.

Of the 49 endemic and restricted-range species known from the region, 29 (8 plants, 9 birds, 1 amphibian, 6 reptiles, and 5 invertebrates) occur in the biodiversity study area or are expected to occur in the biodiversity study area based on habitat conditions (see Table 4-13). These 29 species include 13 local endemics, 11 regional endemics, and 5 range-restricted species. Table 4-13 summarizes key information of the local and regional endemic species as well as the range-restricted species and includes their conservation status, endemism, habitat requirements, and their known geographic distribution and population status, where known.

Figure 4-40: Local Endemic Scorpion *Tityus pictus* Observed at Exploration Drill Pad W1

Figure 4-41: Regional Endemic Species *Spharodactylus vincenti* Observed at Exploration Drill Pads W1 and W3

Figure 4-42: Local Endemic Butterfly *Pseudolycaena cybele* Observed at Exploration Drill Pad W1

Figure 4-43: Local Endemic Subspecies Underwood's Spectacled Tegu *Gymnophthalmus underwoodi* Observed at Exploration Drill Pads W1 and W3

Table 4-13: Rare and Endemic Species Known or Expected to Occur in the Biodiversity Study Area

Taxa/Species (*Scientific name*, common name)	IUCN Red List Status	Endemism (Local, Regional, not endemic)	Habitat Requirements	Distribution and Population Status	Location Observed or Likely to Occur (EDP1, RP1, EDP3, RP3, General Biodiversity Study Area)	Transient (T) or Regular (R) Use
Vegetation						
Begonia pensilis	None	Local endemic	Shady, wet forest areas and transition zones close to the forest	Found only in St. Vincent	General biodiversity study area	Not applicable
Henriettia triflora Ashes wood	None	Regional endemic	Understory in lower montane and montane rainforest, often in partially open spots	Martinique, St. Lucia, St. Vincent, Grenada	EDP1, EDP3 and general biodiversity study area; likely to occur in RP1 and RP3	Not applicable
Lobelia cirsiifolia Burn eye	None	Regional endemic	Shady, very wet habitats, especially roadsides close to the forest	St. Kitts, Dominica, Martinique, St. Lucia, St. Vincent, Grenada	EDP1 and likely to occur in other sites	Not applicable
Ocotea eggersiana Black sweetwood	None	Regional endemic	Lower portion of lower montane rainforest	Guadeloupe, Dominica, Martinique, St. Lucia, St. Vincent, Grenada	EDP1, EDP3 and general biodiversity study area	Not applicable
Sapium grandulosum (=caribaeum) Burn lime	None	Regional endemic	Semi-evergreen seasonal forest and lower montane rainforest	Antigua, St. Kitts, Montserrat, Guadeloupe, Marie Galante, Dominica, Martinique, St. Lucia, St. Vincent, Grenada	EDP1, EDP3 and general biodiversity study area	Not applicable
Pouteria semicarpifolia Contrevent	None	Regional endemic	Lower montane rainforest	Guadeloupe, Marie Galante, Dominica, Martinique, St. Lucia, St. Vincent	EDP1 and general biodiversity study area	Not applicable
Smilax guianensis Wiss vine	None	Regional endemic	Deciduous and semi-evergreen seasonal forest	Antigua, Saba, St. Eustatius, Guadeloupe, Dominica, Martinique, St. Lucia, St. Vincent	EDP1, EDP3 and likely to occur in RP1, RP2 and general biodiversity study area	Not applicable
Tetrazygia discolor Candle wood	None	Regional endemic	Openings in semi-evergreen seasonal forest and roadsides	Antigua, Saba, St. Kitts, Nevis, Montserrat, Guadeloupe, Marie Galante, Dominica, Martinique, St. Lucia, St. Vincent, Grenada	EDP3 and likely to occur in EDP1, RP1, RP3 and general biodiversity study area	Not applicable

Taxa/Species (*Scientific name*, common name)	IUCN Red List Status	Endemism (Local, Regional, not endemic)	Habitat Requirements	Distribution and Population Status	Location Observed or Likely to Occur (EDP1, RP1, EDP3, RP3, General Biodiversity Study Area)	Transient (T) or Regular (R) Use
Birds						
Amazona guildingii St. Vincent Parrot	VU	Local endemic	Confined to mature rainforest between 125 and 1,000 masl, mostly in the upper reaches of the Buccament, Cumberland, Colonarie, Congo-Jennings-Perseverance and Richmond Valleys, although individuals do stray to nearby farmland and plantations to forage	Found only in St. Vincent; Population is estimated to be about 800 in the wild	EDP1, EDP3, RP1, RP3, general biodiversity study area	R
Tangara cucullata Lesser Antillean Tanager; Princebird	LC	Regional endemic	Forests, gardens, and second growth vegetation at all elevations	Uncommon resident known only from St. Vincent and Grenada; Population status is unknown	EDP3, general biodiversity study area	R
Cinclocerthia ruficauda Brown Trembler	LC	Restricted–range Species	Wet forests, and secondary forest and drier woodlands	Fairly common resident in Saba, Guadeloupe, and Dominica; uncommon in St. Christopher, Nevis, Montserrat, St. Lucia, and St. Vincent; rare in Martinique and Grenada; These islands comprise the entire range; Population status is unknown	EDP1, EDP3, general biodiversity study area	R
Eulampis jugularis Purple-throated Carib	LC	Restricted–range Species	Mountain forest and banana/*Musa* spp. Plantations; occasionally sea level	Limited to Lesser Antilles; Fairly common resident on St. Bartholomew, Saba, Guadeloupe, Dominica, Martinique, St. Lucia, St. Vincent, and Grenada; uncommon on St. Eustatius, St. Christopher, Nevis, Antigua, and Montserrat. Vagrant elsewhere; Population status is unknown	EDP1, EDP3, general biodiversity study area	R

Taxa/Species (*Scientific name*, common name)	**IUCN Red List Status**	**Endemism (Local, Regional, not endemic)**	**Habitat Requirements**	**Distribution and Population Status**	**Location Observed or Likely to Occur (EDP1, RP1, EDP3, RP3, General Biodiversity Study Area)**	**Transient (T) or Regular (R) Use**
Loxigilla noctis Lesser Antillean Bullfinch	LC	Restricted–range Species	Shrubbery, gardens, thickets, and forest understorey at all elevations	Common resident throughout the Lesser Antilles, including St. Vincent but absent from the Grenadines; Locally common in Virgin Islands (St. John, St. Croix); These islands comprise entire range; Population status is stable	EDP1, EDP3, general biodiversity study area	R
Myiarchus nugator Grenada Flycatcher	LC	Regional endemic	Open areas around settlements and lowland scrub, especially near palms.	Common resident known only from St. Vincent, Grenadines, and Grenada at all elevations; Population trend is decreasing	EDP1, EDP3, RP2, general biodiversity study area	R
Orthorhyncus cristatus Antillean Crested Hummingbird	LC	Restricted–range Species	Primarily lowland openings, gardens, forest edges, and arid habitats; also mountain forests	Common resident throughout Lesser Antilles, Virgin Islands, and on Puerto Rico's northeastern coast; Range expanding to Puerto Rico; Population status is unknown.	EDP1, EDP3, RP1, general biodiversity study area	R
Eulampis holosericeus Green-throated Carib	LC	Restricted–range Species	Gardens and rain forests at all elevations in the Lesser Antilles	Common resident throughout the Lesser Antilles, Virgin Islands, and northeastern Puerto Rico; Population status is unknown.	EDP1, EDP3, general biodiversity study area	R
Troglodytes aedon musicus St. Vincent House Wren	LC	Local endemic subspecies	Moist upland forests to arid coastal areas and human settlements	*T. aedon* population is increasing but no assessment has been completed for the endemic subspecies; Population status is unknown	EDP1, EDP3, RP1, general biodiversity study area	R

Taxa/Species (*Scientific name*, common name)	IUCN Red List Status	Endemism (Local, Regional, not endemic)	Habitat Requirements	Distribution and Population Status	Location Observed or Likely to Occur (EDP1, RP1, EDP3, RP3, General Biodiversity Study Area)	Transient (T) or Regular (R) Use
Reptiles						
Anolis griseus St. Vincent tree anole	None	Local endemic	Primarily arboreal and observed 2-8 meters above the ground, with females and juveniles slightly lower than males; Rare or absent if vegetation is sparse	Widely distributed throughout St. Vincent; Population status is unknown	EDP1, EDP3, RP1, RP3, general biodiversity study area	R
Anolis trinitatus St. Vincent bush anole	None	Local endemic	Found in all but the most heavily disturbed, sparsely vegetated habitats	Widely distributed throughout St. Vincent; Population status is unknown	EDP1, EDP3, RP1, RP3, general biodiversity study area	R
Gymnophthalmus underwoodi Smooth-scaled worm lizard, Underwood's spectacled tegu	LC	Local endemic subspecies	Generally abundant in leaf litter	Antigua and Barbuda; Barbados; Bonaire, St. Eustatius and Saba (St. Eustatius); Brazil; Colombia; Dominica; French Guiana; Grenada; Guadeloupe; Guyana; Martinique; St. Lucia; St. Vincent and the Grenadines; Suriname; Trinidad and Tobago; Venezuela, Bolivarian Republic of; Virgin Islands, U.S.	Observed in EDP1 but likely to occur in other sites	
Sphaerodactylus vincenti vincenti Windward dwarf gecko	LC	Local endemic subspecies	Generally abundant in leaf litter	Dominica, Martinique, St. Lucia, St. Vincent and the Grenadines; Population is stable	EDP1 and EDP3 but likely to occur in other sites	R
Mastigodryas brusei White snake, Windward racer	None	Regional endemic	Found in relatively dry habitats including forest and plantations as well as gardens, urban, and other suburban habitats	Found in Grenada and St. Vincent and the Grenadines; Population status is unknown	Observed in EDP3 likely to occur in other sites	R

Taxa/Species (*Scientific name*, common name)	IUCN Red List Status	Endemism (Local, Regional, not endemic)	Habitat Requirements	Distribution and Population Status	Location Observed or Likely to Occur (EDP1, RP1, EDP3, RP3, General Biodiversity Study Area)	Transient (T) or Regular (R) Use
Corallus cookii Congo Snake	None	Local endemic	Widely distributed in lowlands and to elevations of about 450 masl; Very common in suburban gardens; Essential habitat feature is contiguous tree canopy.	Found only in St. Vincent; Population status is unknown	Not observed but likely to occur in all sites	R
Amphibians						
Pristimantis shrevei St. Vincent Whistling Frog	EN	Local endemic	The species is arboreal, occurring in rainforest, forest edge, and montane meadows surrounded by agriculture. Individuals occur on the ground and on vegetation, generally at higher elevations (>300 masl) and are abundant on the highest peaks (~980 masl), even at the rim of La Soufrière Volcano.	Found only in St. Vincent; Population is decreasing	EDP1	R
Invertebrates						
Chiomara (asychis) vincenta White-patterned skipper	None	Local endemic	Pastures, grasslands, gardens, and forest edge	Widely distributed throughout St. Vincent; Population status is unknown	Observed in EDP1 and EDP3 and likely to occur in other sites	R
Dryas iulia framptoni Flambeau or Julia's butterfly	None	Local endemic subspecies	Pastures, grasslands, gardens, and forest edge	Surinam, Bolivia, Brazil, Dominica, Jamaica, Dominica, Cuba, Dominican Republic, Puerto Rico, Honduras, Mexico, St. Lucia, St. Kitts, Florida, Cayman Islands, Ecuador, St. Vincent; Population status of local endemic subspecies is unknown	Observed in EDP1 and EDP3 and likely to occur in other sites	R

Taxa/Species (*Scientific name*, common name)	**IUCN Red List Status**	**Endemism (Local, Regional, not endemic)**	**Habitat Requirements**	**Distribution and Population Status**	**Location Observed or Likely to Occur (EDP1, RP1, EDP3, RP3, General Biodiversity Study Area)**	**Transient (T) or Regular (R) Use**
Pseudolycaena cybele St. Vincent hairstreak	None	Local endemic	Forest edge and forest	Found only in St. Vincent; Population status is unknown	Observed in EDP3 and likely to occur in EDP1	R
Polites dictyana Lesser whirlabout (skipper)	None	Regional endemic	Pastures, grasslands, gardens, and forest edge	St. Vincent and Grenada; Population status is unknown	Observed in EDP1 and EDP3	R
Tityus pictus Scorpion	None	Local Endemic	Dry logs, branches, and leaf litter	Found only in St. Vincent; Population status is unknown	Observed in EDP3 but likely to occur in other areas	R

IUCN = International Union for the Conservation of Nature; masl = meters above sea level; EDP = exploration drill pad; RP = Injection pad; T = transient; R = regular

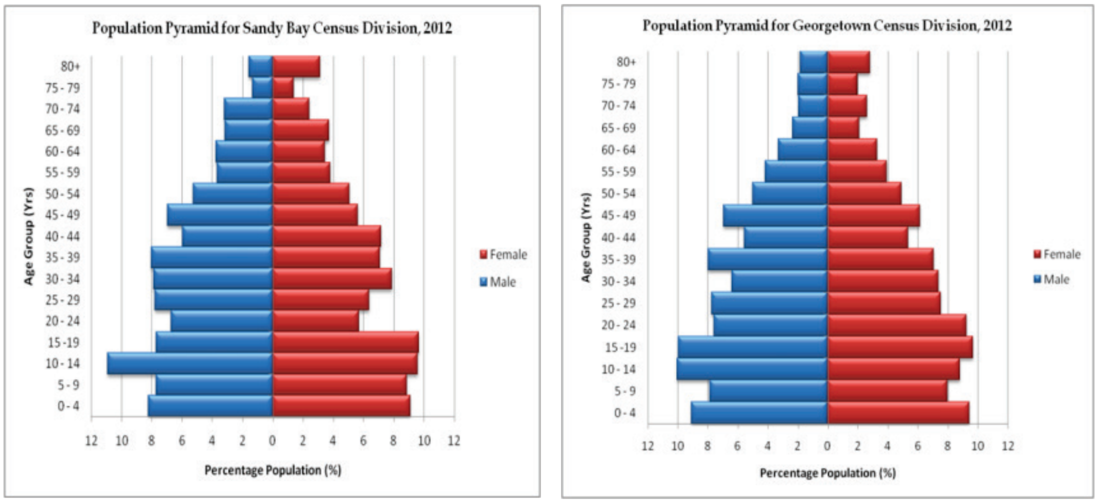
4.3 SOCIOECONOMIC AND HEALTH BASELINE

This section describes the baseline socioeconomic and health characteristics of the Project Area and the surrounding settlements that could be affected by the Project. It was developed based on secondary information contained in Project-related materials (e.g., Scoping Reports, Resettlement Action Plan); documents provided by the SVGCL; socioeconomic reports and data obtained through SVG government entities; and other relevant data received from public sources. It is also based on information obtained directly from semi-structured interviews with members of local settlements and communities, Government of SVG, and other Project stakeholders during the February 2016 site visit. The results of these interviews are presented by topic in the relevant subsections of this Chapter.

4.3.1 Population and Demographics

In 2014, the population for SVG was 109,360. Over the past decade, typical population growth has been steady at approximately 0.1 percent year-on-year (World Bank 2016). St. Vincent's topography limits the population density and distribution. The majority of development on St. Vincent is coastal, with the main population centers located on a narrow strip around the border of the island, less than 5 km from the high-water mark, and less than 5 m above sea level. Most major settlements are located along the coastline with some 25 percent of the population being concentrated in the southern regions. Density levels across census divisions vary significantly depending upon access to jobs, education, health care, and other amenities.

The Project Area straddles two census districts (out of a mainland island total of 11 census districts) – Georgetown and Sandy Bay. The 2012 population census recorded 7,049 persons (2,188 households) in the Georgetown Census district and 2,576 (662 households) in the Sandy Bay census district (SVG Statistics Office, Population Census Data 2012). The population breakdown is provided in Figure 4-44 and further broken down in Section 4.3.3, *Introduction to Project-Affected Communities*.



Source: The Geothermal Consortium 2015a

Figure 4-44: Population Pyramids for Sandy Bay and Georgetown from 2012 Census

SVG is an upper-middle-income country with a per capita gross national income (purchasing power parity adjusted) of USD$10,510 in 2013. The Human Development Index value for 2012 was 0.733—in the high human development category—positioning the country at 83 out of 187 countries and territories (World Bank 2016).

Approximately 90 percent of the population is of African descent, while the other 10 percent is a combination of East Indian, European, and indigenous people. Economic development centers around agriculture, tourism, and international business services sectors. The literacy rate is 96 percent, and the life expectancy at birth is 74 years (World Bank 2016)

4.3.2 *Vulnerable Groups and Indigenous Peoples*

The Yellow Caribs or the Kalinago were the first noted inhabitants of SVG. The composition of the Kalinago people changed with the introduction of African slaves who came to the Caribbean on the advent of the sugar revolution. This amalgamation of the races gave rise to the "black Caribs" or the Garifuna people. Today, although there are some descendants of the indigenous peoples living in the northeastern communities surrounding the La Soufrière Volcano, the population is made up of people of various ethnic backgrounds (The Geothermal Consortium 2015a).

This ethnic mix in the northeast region of St. Vincent was historically excluded from the development experienced in other parts of the island, and continues to have higher levels of poverty and reliance on natural resources, primarily agriculture and fishing (Murray 2014). The northwest region of St. Vincent has also developed separately from other parts of the country, due to the difficulty of commuting to Kingstown. In Sandy Bay, there are descendants of the original

Carib inhabitants of the island (Murray 2014); however, they generally cannot be distinguished from the general population.

Garifuna communities in St. Vincent do not exist within the Project Area and thus would not be affected directly by the Project (RG and LPH 2013). However, there are vulnerable groups, including women, youths, widows, elderly people, mentally challenged, and physically handicapped, within the Project Area who will need to be considered appropriately. There is a mental hospital temporarily located at the base of Feeder Road W1. Government of SVG officials have confirmed that this mental hospital will be relocated to its new permanent site during the summer of 2016.

4.3.3 *Introduction to Project-Affected Communities*

Project-Affected Communities are the populations residing in the nearest settlements to the Project Area, including residents and farmers near exploration drill pads W1 and W3 and injection pads W1 and W3, as well as those residing and working along the existing feeder roads leading from Windward Highway to sites W1 and W3. These include the settlements located along the coastline approximately 3 to 4 km from the Project layout area, considered as the AoI, namely Sandy Bay, Overland, Orange Hill (including Waterloo and Tourama), Langley Park (including Chapmans and Basin Hole), and Georgetown, which is considered the nearest settlement to the Project site with the most advanced social infrastructure. Project-Affected Communities also include farmers who own or lease land in the direct Project footprint. The location of Project-Affected Communities in relation to the Project Area is shown in Figure 4-45.

The total population of these settlements as detailed in the SVG 2012 Census (SVG Statistic Office 2012) is:

- Sandy Bay 1, 2, 3 and 4 = 945 people (231 households)
- Overland and Big Level 1, 2, 3 = 1,440 people (342 households)
- Waterloo, Orange Hill, and Tourama = 326 people (106 households)
- Chapman’s, Langley Park and Basin Hole = 687 people (216 households)
- Georgetown 1, 2, 3 = 892 people (314 households)

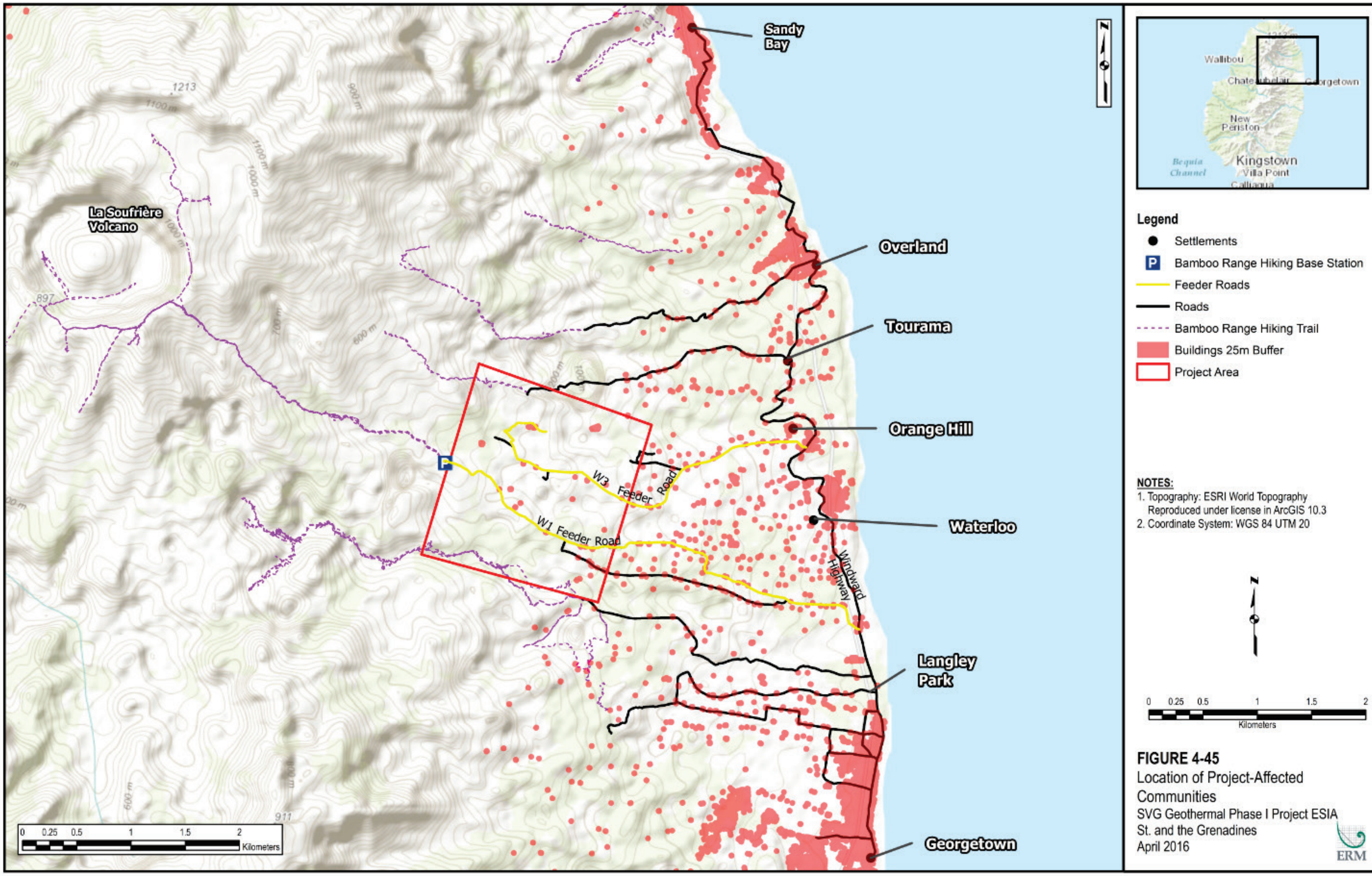


Figure 4-45: Location of Project-Affected Communities

These communities are located in two of the poorest census districts in the country, Georgetown District and Sandy Bay District, where 55.6 percent of residents are considered poor, as compared with 18.8 percent nationally (Murray 2014). Aside from Georgetown, a majority of these communities are involved in small-scale farming and the land within and close to the Project Area is a mixture of agricultural land, virgin forest, and settlements, including homes, roads, paths, and commercial buildings.

The working age population for these two districts is 7,046 of which approximately 74 percent are employed, making unemployment about 26 percent. In terms of living conditions, 82.2 percent of households are connected to VINLEC power supply. Fourteen households (including the one in focus) representing 0.005 percent of the population use private diesel generators. Sixty-eight percent (68 percent) of homes are modern concrete block structures with potable water indoors and water closets. The Government of SVG housing program has built 90 of these houses over the past 10 years.

While only 45 percent of the population completed elementary school, secondary school places (i.e., government-allocated slots) are now available for all persons between the age of 11 and 18. However, only 80 percent of these places are taken. There are primary and secondary schools in these districts and transportation is provided for students not living in proximity to the schools (RG and LPH 2013).

Increasingly, rich urban dwellers and St .Vincentians returning from overseas have sought housing in the Sandy Bay/Georgetown area as it is located in an attractive rural landscape but relatively close to the facilities of Kingstown, especially with the continuing improvements of the Windward Highway. The net "outcome" of these changes has been a relatively stable population, punctuated with periods of growth and decline (RG and LPH 2013).

Given the relatively small size of the Project-Affected Communities, it is common for residents of one community to know a majority of the other residents in their own settlement as well as other neighboring areas. During the scoping consultations carried by SVGLCL, approximately 85 percent of persons interviewed in these areas had some knowledge of the plans for geothermal exploration. This was a consistent statistic during the informal community interviews conducted in February 2016 by ERM. The radio as well as community consultations were cited as the main sources of information, and some persons had obtained their information from other persons in the community.

As there is high unemployment in the communities sampled, it was not surprising that more than 45 percent of those interviewed welcomed the Project with the hope that it would provide them with job security (The Geothermal Consortium 2015b).

Other affected local populations outside of the Project-Affected Communities include landowners and users along the Windward Highway from Kingstown to Sandy Bay and local people occasionally using areas within the Project Area for traditional or recreational activities (e.g., fishing, hunting, hiking).

4.3.4 Economic Activities

The main sources of income in SVG are farming and tourism. In 2014, the proportion of gross domestic product (GDP) from the services sector (including tourism) was 75.2 percent (up from 74.2 percent in 2011), industrial sector was 17.1 percent (down from 18.4 percent in 2011), and the agriculture sector was 7.8 percent (up from 7.5 percent in 2011). Although it has decreased in recent years, banana continues to be the main crop; nationally, other crops have expanded as well (e.g., cassava, eddoe, dasheen yam, sweet potato) due to the Government of SVG's implementation of structural reforms to diversify crops.

Small-scale subsistence farming is a common economic activity, even though residents often do not perceive it as employment. Banana, cassava, pigeon peas, sweet potatoes, yams, and arrowroot are the main crops produced in the area. Many residents have between one and five animals that they tend; only several have larger numbers of livestock (between 20 to 50) (Murray 2014). During the February 2016 site visit, informal interviews with day farmers found that they average 40 Eastern Caribbean Dollars (XCD) per day to farmlands within the Project Area. Meanwhile, small-scale farmers who sell their crops on the local market (on the main roads and to local shopkeepers) average XCD 80 per sack of potatoes and XCD 40 to XCD 80 per pound for bananas, depending on supply and demand.

Marijuana cultivation also employs some individuals in the Project Area, but this is not a significant proportion of residents.

Tourism is an important activity in the country as well as in the Project Area (see Section 4.3.5 below). Waterfalls, beaches, recreational parks, and nature trails in the northern part of the island attract tourists and provide additional employment through support services such as construction and fishing (Murray 2014).

Others in the Project Area are employed via local enterprises, such as shopkeepers and vendors, or as salaried employees, such as in public service, police service, medical services and, the education system.

4.3.5 Tourism, Recreation, and Leisure

As noted in Section 4.3.4, *Economic Activities*, tourism is a major contributor to the economy. The nation prides itself on its rainforests and natural beauty to attract tourists for ecoadventures, yachting, scuba diving, hiking, and relaxing. One of the most popular tourist attractions on St. Vincent is the La Soufrière

Volcano, which attracted 6,335 visitors in 2015 (see Table 4-14). Bamboo Range Hiking Base Station is located within the Project Area.

Table 4-14: Annual Visitors to La Soufrière Volcano

Year	2012	2013	2014	2015
Total Annual Visitors	4,887	4,179	4,503	6,335
Local Visitors	2,696	2,356	2,568	3,310
Foreign Visitors	2,191	1,823	1,935	3,025

Source: Ministry of Tourism 2016

According to local tour guides who are employed by the National Park, those guides who are registered with the Government of SVG must submit monthly counts of tourists who visit the La Soufrière Volcano. These statistics are then tallied by the Ministry of Tourism and monitored on a monthly basis. According the data, the peak months for foreign tourists to the La Soufrière Volcano are December through February. However, local tourists continue to visit the site throughout the year.

There are no other significant tourist or recreation attractions within the Project Area.

4.3.6 *Land Use, Ownership, and Housing*

The Government of SVG is a major landholder, owning 60 percent of total land in the country (RG and LPH 2013). The north region of St. Vincent is primarily state-owned forest reserves. Amongst those surveyed during the 2014 baseline study, over 90 percent in the Project area claimed to reside on lands that they own; of these, half reported having legal title to this land; none reported that they were squatting on the land (Murray 2014). A very small proportion reported that they lease or act as caretakers for other landowners, who may live in the local community or abroad.

The other land holding arrangement discovered during the scoping meetings and subsequently confirmed in the ERM February 2016 site visit was a caretaker arrangement where the occupant was managing the land for relatives overseas. Most of the lands in the northern third of St. Vincent are Crown lands and/or state-owned forest reserves.

Although the national building code prohibits the construction of houses on steep slopes, this still occurs in rural communities (Murray 2014). Houses are most commonly constructed using concrete blocks, even in poor communities, although the very poor sometimes use plywood or scrap material. Families, which average five per household, tend to live in individual houses (Nippon Koei *et al.* 2015).

Individual house ownership is norm; housing (structure, size, and location) is a function of socioeconomic standard. The very poor may construct their own houses from plywood or material salvaged from demolished structures. Throughout the Project Area, there are a mixture of metal "banana shack" structures which farmers utilize to store crops and materials. The general locations of residential and non-residential structures within the Project Area and Project-Affected Communities are depicted in Figure 4-46 below. As shown, structures are scattered throughout the agricultural lands, with the majority of clusters (which are primarily residential) located within the settlements.

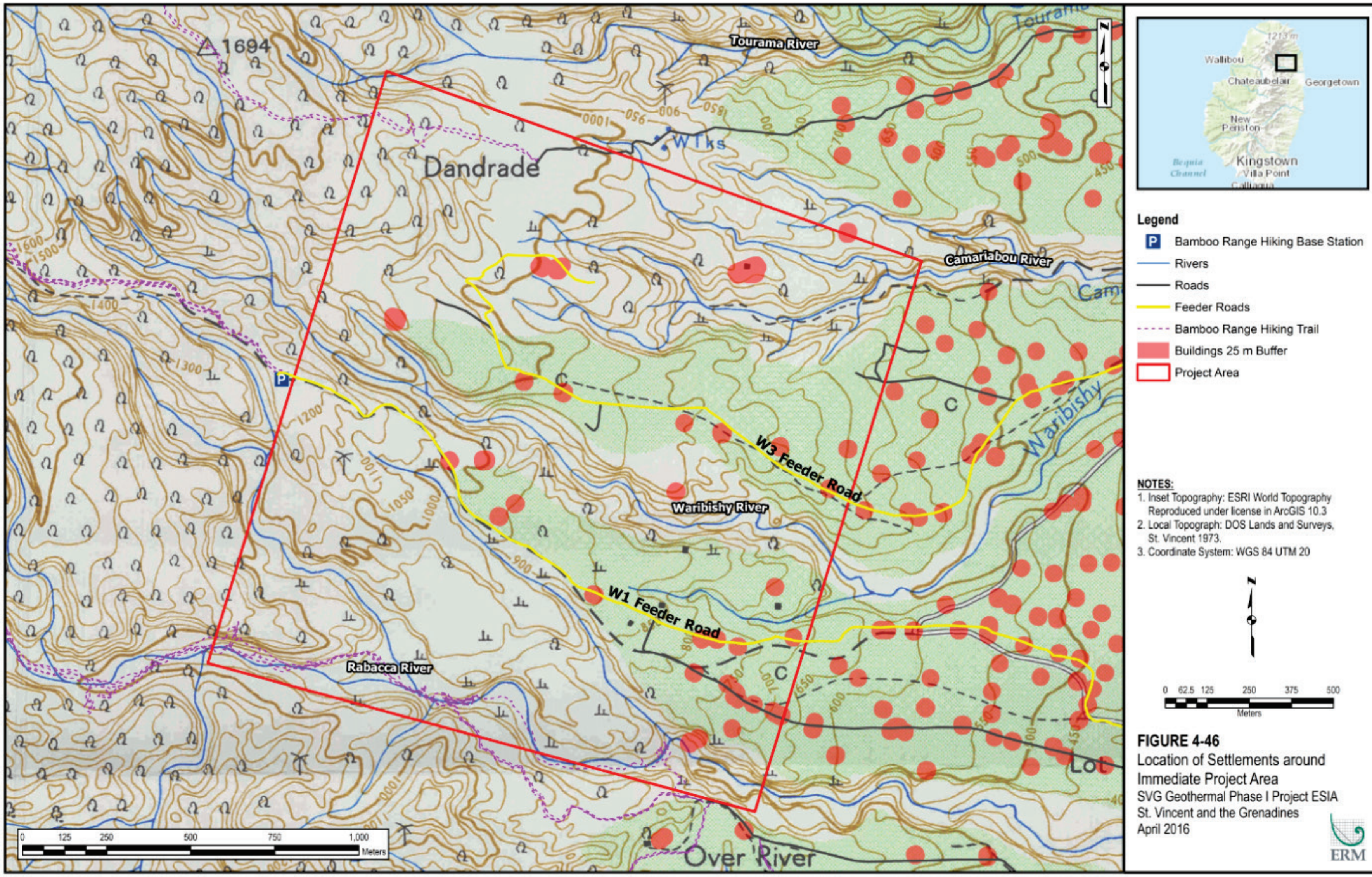


Figure 4-46: Location of Settlements around Immediate Project Area

Although residents are allowed to own lands and obtain legal title to parcels of land, the power of eminent domain exists, which allows the Government of SVG to access private property and convert it into public use as necessary. According to Government of SVG officials, limited land resources and land availability in the country is always a primary policy concern. There is a good partnership with the Government of SVG and the farmers in the Project area. Communities know that the Government of SVG is willing to make concessions for communities to help them, yet they also understand that limited resources means cost effective solutions are often sought.

4.3.7 *Social Infrastructure and Services*

Most of the infrastructure on the island of St. Vincent is located in the south near Kingstown, with less social infrastructure in the north. Potable water is piped for free to most of the population, except for 2 percent that use natural spring or rain water. Within the Project area, the primary source of water is the Government of SVG's piped water to residential structures and businesses, with farmers utilizing rainwater harvesting as the primary method for providing water to crops and livestock. Many residents also use the river, though, for activities such as washing clothes, watering plants, and caring for animals; water is considered to be of good quality, except during heavy rain events when it fills with silt. While there is no quantitative data on the number of river water users, informal interviews with local residents suggest that these practices have diminished significantly over the past several years since the SVG installed piped water into the area.

A full 95 percent of households access bottled gas. Ten percent of residents lack indoor/flushing toilets and instead use pit latrines (the construction of which is supervised by public health authorities). Approximately half of the population has access to a landline phone, and over 90 percent have mobile phones.

The roads leading from the leeward side of the island to Kingstown are over 30 years old and are showing the effects of heavy use coupled with tropical weathering. On the east, the roads are more recent but are showing the effects of weathering due to floods over the past 4 years. These roads are somewhat dilapidated due to flooding in recent years; electricity and water lines can go down as a result of flooding but they are generally replaced immediately. VINLEC, the only public electricity provider in the country, provides electricity to as many as 70 percent of households in some areas (Murray 2014). Informal interviews and household visits suggest this percentage likely applies to those residing within the Project area.

Churches, common throughout the Project Area and the AoI, are often used as social outlets, and act in many cases as community centers. Churchgoers utilize weekly services for information dissemination and generally socializing.

4.3.8 *Community Health, Safety, and Security*

The epidemiological profile of SVG resembles that of a developed country, which has very low levels of infectious disease and a high percentage of chronic diseases. Key health issues in SVG are HIV/AIDS, non-communicable diseases such as diabetes, hypertension, and obesity, motor vehicle accidents, and criminal violence (RG and LPH 2013). Table 4-15 below summarizes the key basic health indicators for the country.

Table 4-15: Recent Basic Health Indicators for SVG

Key Health Indicators for SVG Indicators	Scores	Most Recent Year
Life expectancy	72 years	2009
Infant mortality rate per 1000	16.8	2010
Maternal mortality rate per 1000	1.1	2010
Fertility rate (child/woman)	1.8	2008
Perinatal mortality rate per 1000	32.5	2010
Registered nurses per 1,000 population	25.8	2010
Physicians per 10,000 population	6.6	2010
Hospital beds per 1000 population	2.8	2010
Births attended by skilled personnel	98.3%	2010
Total expenditure on health	USD$55.4 million	2010
% health expenditure of GDP	3.7	2009
Calories consumed per day	2,660	2004
Population with access to drinking water (mainland)	96.0%	2008

% = percent; GDP = gross domestic product

Source: Nippon Koei *et al.* 2015

As shown above, the quality of medical care in SVG is considered high: for instance, nearly all births are attended to by skilled personnel; all children under age five are immunized; and life expectancy at birth is high. Health care services are readily available via district hospitals, community clinics, and Family Nurse Practitioners who travel to provide services for schoolchildren and those suffering from diabetes and hypertension (Nippon Koei *et al.* 2015). Despite the level of health reflected by the data in Table 4-15, the country has seen increases in chronic, non-communicable diseases, which are now responsible for the majority of deaths (Nippon Koei *et al.* 2015). The districts of Georgetown and Sandy Bay are no exception to this rule; Table 4-16, below details instances of chronic illnesses in the two districts.

Table 4-16: Instances of Chronic Illness in the Districts of Georgetown and Sandy Bay, 2012

Chronic Illness	Georgetown	Sandy Bay
Diabetes	479	169
Sickle Cell Anemia	68	34
Arthritis	362	163
Asthma	335	168
Hypertension	718	326
Heart Disease	62	36
Stroke	32	8
Kidney Disease	20	10
Cancer	17	9
Lupus	2	8
Carpal Tunnel Syndrome	2	0
Glaucoma	45	4
None	5300	1813
Other	179	103

Source: Nippon Koei *et al.* 2015

Lifestyle diseases (hypertension and diabetes) are the major forms of illness in the Georgetown and Sandy Bay census districts, which mirrors the national statistics.

Within the Project Area, the nearest health facility is the Georgetown Hospital, which is a basic clinical facility with an on-call doctor focused on minor injuries only. The hospital lacks sophisticated medical equipment, although a new diagnostic center is currently under construction on the compound. All medical care is free except for overnight stays where the patient is charged XCD 10 per night. The hospital refers all medical cases they cannot care for to Kingstown Hospital. The statistics for January 2016 obtained from the hospital's information board are provided in Table 4-17 below.

Table 4-17: January 2016 Georgetown Hospital Medical Cases

Type	Total	Female	Male
Admissions	20	13	7
Child delivery	7	3	4
Casualties	300	150	150
Lacerations	123	66	57
Diabetes	2	2	0
Hypertension	11	5	6
Diabetes Mellitus /Hypertension	12	6	6
Fever	11	5	6
Asthmatic	13	5	8
Gastro	0	0	0
Referrals	11	8	3
Observation	20	11	9
Police	0	0	0
Tuberculosis Booster	0	0	0

Within the Project Area, there is also the Sandy Bay Clinic that operates on a Monday through Friday "normal working hours" schedule with nurses available to care for cases of hypertension, diabetes, dressings, antenatal, child health, family, and planning. A doctor is available 1 day of the week. A majority of patients are farmers who seek medical help for primary conditions related to hypertension, diabetes, and asthma. According to a staff member at the facility, cases of rape, abuse, and underage pregnancy (14 years old and below) have been on the rise over the past year and authorities are not addressing these issues.

According to police staff at the Georgetown and Sandy Bay Police Stations, petty theft is the most common crime within the Project Area, but statistics are generally low. During informal interviews with farmers in Rabacca Hills and Orange Hill agricultural lands in February 2016, there were several complaints of theft of livestock and farming equipment occurring at night when farmers are away at their residences downhill in the settlements. Police claim to have stepped up patrols along Orange Hill because of these thefts. During informal interviews of the February 2016 site visit, police officers claim that prostitution is not a concern in these census districts, although local health officials assess it is more common than acknowledged.

In regards to Marijuana farmers in the Project Area, police claim that the farmers would relocate away from the drilling sites once activity begins. However, tour guides of La Soufrière Volcano who exchange information on the whereabouts of police for freedom to move along the trails (which the Marijuana farmers frequent) disagree. They claim the farmers always look to take advantage of foreigners in the area to increase sales. All groups informally interviewed said there is a consistent low likelihood of conflict between foreigners and locals within the Project Area due to the general acceptance of foreign tourists in the area due to the income they bring to the region and nation more generally.

According to police, possession over 15 grams of Marijuana for foreigners can result in prison time; however, police tend to only issue warnings.

4.3.9 Transportation and Traffic

4.3.9.1 Road System

The Project access route is Kingstown Port to the Project site via the Windward Highway and two feeder roads (see Figure 4-47). Physical and traffic characteristics of those roads are discussed below.

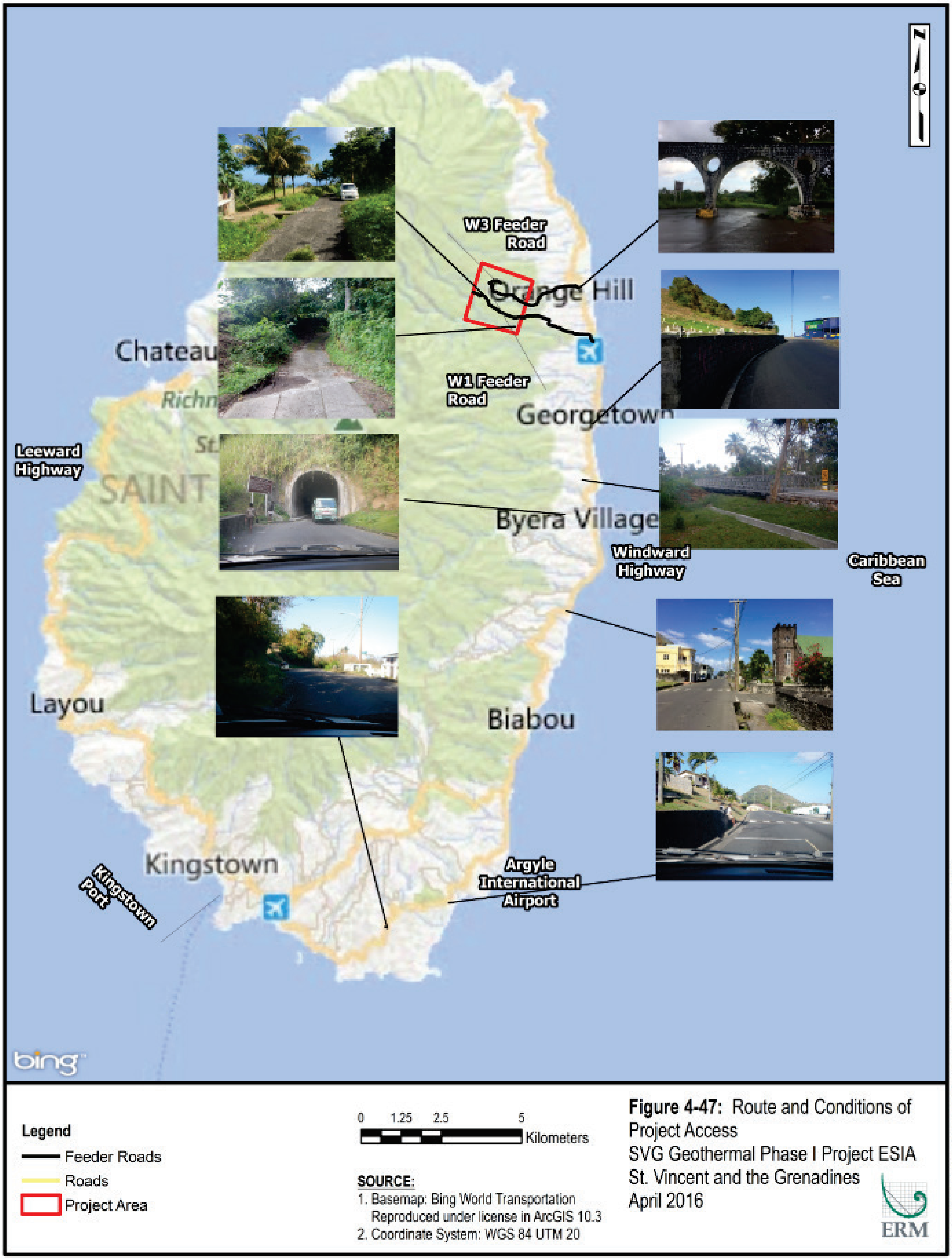


Figure 4-47: Route and Conditions of Project Access

4.3.9.1.1 Description of Road System

The primary roads on the island of St. Vincent run mainly along the perimeter of the island, including the Windward Highway; generally, secondary roads provide access inland (Stantec 2015).

4.3.9.1.1.1 Windward Highway

The Windward Highway runs along the east (windward) side of the island, from Kingstown to Orange Hill, near the island's northernmost point (see Figure 4-47). Windward Highway is a winding road with steep grades and sharp turns. As part of upgrades completed in approximately 2009, the highway was widened to its current 5 to 7 m typical width (plus shoulders on both sides), and some sharp turns and steep grades were addressed (Stantec 2015).

There are 24 bridges, 19 culverts, and 1 tunnel (the Byrea Tunnel) along the Windward Highway route from Kingstown harbor to the vicinity of the Project Area (Stantec 2015). In its Project-specific survey, Stantec determined that these structures "were all generally found to be in a satisfactory condition and suitable for transport" (Stantec 2015).

Two ongoing bridge repairs could affect Project transportation, including reconstruction of the Grand Sabel and Byran bridges. Temporary bridges are in place at both locations, and repairs to the existing bridges are expected to be complete by the end of September and December 2016, respectively.

4.3.9.1.1.2 Feeder Roads

Access to the W1 site would be via a feeder road originating at the Windward Highway just north of the Rebacca Dry River (see Figure 4-47). The feeder road is a 4.5 m wide paved road, which also serves as the primary public access to the La Soufrière Volcano hiking trails and associated visitor station (Stantec 2015).

The W3 feeder road originates at the Windward Highway near the Orange Hill aqueduct (north of the W1 feeder road, see Figure 4-47). The W3 feeder road is also paved, although the pavement as well as the geometry of the intersection with Windward Highway would require upgrades in order to accommodate Project drilling activities (Stantec 2015).

4.3.9.1.2 Existing Road Traffic and Safety Considerations

Data on road traffic volumes in SVG is not readily available. Traffic on the Windward Highway is heaviest between the Kingstown port and Kingfield forest, and generally does not experience significant variation from weekday to weekday. Segments of Windward Highway outside of Kingstown are often characterized by slow-moving traffic (Bailey 2016).

As part of the February 2016 site visit, ERM observed traffic behavior on the Windward Highway and other roads. While drivers generally obeyed traffic laws, it was not uncommon to see vehicles stopped along the road (i.e., adjacent to a market), even though doing so essentially blocked one lane of traffic. Pavement markings on Windward Highway were intermittently present.

Windward Highway is commonly used by children walking to school. This pedestrian activity typically begins at 08:45 a.m. on weekdays, with the reverse trip typically starting at approximately 3:00 p.m. The afternoon school journey blends into the pedestrian journey home for workers, and weekday pedestrian volumes are typically high through approximately 6:00 p.m. Weekend pedestrian volumes on the roads are typically low (Bailey 2016). There are few sidewalks or designated pedestrian paths along the public roads outside of Kingstown.

Safety hotspots and other areas of concern include the Muratha Mill area at the road's southernmost point—a hotspot for vehicular accidents—as well as the area near Guilds High School, due to student pedestrian activity (Bailey 2016).

4.3.9.2 Ports and Marine Traffic

4.3.9.2.1 Description of Ports and Marine Facilities

Kingstown Port is the nation's largest port as well as the main port of entry for both cargo and tourist vessels; it is also the terminus of various ferries between SVG islands (Stantec 2015).

> The Kingstown Port receives and exports containerized cargo in both 6 m and 12 m long containers. There is no dockside gantry crane for offloading containers; container offloading is therefore normally carried out with the assistance of on-board ships cranes. (Stantec 2015)

4.3.9.2.2 Marine Traffic

Ports in SVG received a total of approximately 23,000 containers (measured as twenty-foot equivalent units, or TEUs) in 2013, the most recent year for which data were available (World Bank 2016).

4.3.10 Visual Resources

The slopes of La Soufrière Volcano are covered in agricultural fields, as well as lush tropical vegetation and palm trees (see Figure 4-48). The Bamboo Range recreational trails lead hikers to the summit of the La Soufrière Volcano, which provides a panoramic view of large portions of the island (see Figure 4-49).

Figure 4-48: Area Near Injection Pad W3

Figure 4-49: View from Top of Bamboo Range Hiking Trail

The trail is considered an important recreational and visual resource for both tourists and St. Vincent residents (Representative from physical planning unit 2016).

4.4 CULTURAL HERITAGE BASELINE

The goal of the cultural heritage baseline study was to characterize the types of cultural heritage resources present within SVG that could be impacted by the Project. For the purposes of this study, cultural heritage was defined using the criteria established in Inter-American Development Bank (IDB) Technical Note 896 entitled *Managing the Impacts of IDB Projects on Cultural Heritage* (IDB Technical Note on Cultural Heritage; IDB 2015b) and IFC Performance Standard 8 (IFC 2012). Cultural heritage refers to all physical or tangible cultural heritage resources, which include:

- Moveable or immovable objects, sites, structures, groups of structures, and natural features having archaeological, paleontological, historical, cultural, artistic, and religious values; and
- Unique natural features or tangible objects that embody cultural values.

An important aspect of both the IDB Technical Note on Cultural Heritage and IFC Performance Standard 8 is the applicability of the standards to all cultural heritage resources regardless of whether or not they are protected by the host country laws or regulations. The IDB Technical Note on Cultural Heritage defines four types of tangible cultural heritage resources: archaeological sites/monuments; historic architecture; historic landscapes; and living heritage. Table 4-18 provides definitions for each of these types of resources and examples of each type from the IDB Technical Note.

Table 4-18: Types of Cultural Heritage Resources Identified in the IDB Technical Note

Types of Resources	Examples
Archaeological Sites/Monuments	• Pre- and post-European contact indigenous camps, villages, towns, and cities, building complexes and structures; and • European exploration, conquest, and colonial period sites, including industrial sites or infrastructure of historical importance.
Historic Architecture	• Historic towns and neighborhoods; • Colonial city centers; and • Individual buildings or structures such as ports, canals, bridges, railways and stations, palaces, government offices, cathedrals, churches, military installations, markets, etc.
Historic Landscapes	• Culturally important natural features; • Prehistorically or historically modified landscapes such as terraces or raised-fields, drainage systems, irrigated areas, trails, and plantations; and • Sites where important historic or cultural events have taken place such as battlefields or areas associated with traditional folktales.
Living Heritage	• Churches, chapels, and temples; • Roadside shrines and crosses; • Cemeteries and unmarked burial sites, which may have forensic and political implications; and • Any natural or built sites that is used and/or valued by a specific group or community.

Source: IDB 2015b

The cultural heritage baseline study was divided into two phases: a desktop study and a field survey. The results of the desktop study and field survey are presented in the following sections.

4.4.1 Desktop Study

The desktop study consisted of a review of publically available books, journal articles, Government of SVG internet sites, and cultural heritage databases and consultations with the SVG National Trust and Ministry of Tourism, Culture, and Sport to identify known cultural heritage resources within and near the Project Area, established as the cultural heritage study area. The objectives of the desktop study were to:

- Develop a cultural context/cultural history of SVG in order to identify the types of resources that could be present in the Project Area and to inform assessments of the archaeological or historic significance of resources;
- Obtain information on the location and characteristics of legally protected cultural heritage resources listed on the National Register of Archaeological Sites (NRAS) and National Register of Historic Buildings (NRHB); and
- Collect information on known cultural heritage sites found on SVG in order to assess the potential types of undiscovered resources that could be located within the Project Area.

4.4.1.1 Protected Cultural Heritage Resources

Appendix D provides summary information for the cultural heritage resources listed on the NRAS and NRHB. In addition to their importance as legally protected cultural heritage, these resources provide important information on the types and characteristics of cultural heritage resources viewed as significant by local and national stakeholders. For the purposes of this study, unlisted cultural heritage resources with similar characteristics to those listed are considered as equally significant to these stakeholders and treated the same as nationally protected resources.

4.4.1.2 Cultural Context

Table 4-19 provides a summary of the principal prehistoric and historic periods of SVG from the arrival of the first people on the island ca. 500 B.C. to the present.

Table 4-19: SVG Cultural Context

Period	Description/Significant Events
Saladoid (500 B.C. - A.D. 500)	• Earliest confirmed archaeological sites on SVG • Earliest occupants of the island appear to have migrated to SVG from northeastern Venezuela or Trinidad. • Earliest populations were agriculturalists, cultivating manioc that was cooked on distinctive ceramic "griddles"
Troumassoid (A.D. 500-1000)	• SVG populations continue to practice agriculture with possible increased reliance on shell fish and other marine resources • Archaeological sites representing the remains of small agricultural villages and hamlets
Suazoid (A.D. 1000-1400)	• Shift to plain pottery types with thicker vessel walls, scratched or scraped surfaces, and rims roughened with finger impressions • Diagnostic artefacts include stone grinders and pestles, shell celts, gouges, and scrapers • Archaeological sites representing the remains of small agricultural villages and hamlets
Island Carib/ Garufuna (A.D. 1400-ca. 1700)	• Period marked by arrival of Carib populations from Venezuela/Trinadad, conquering the local Igneri ethnic group. • Beginning in the 17th century, escaped African slaves and African slaves taken during raids on European settlements settled on the island and began intermarrying with indigenous peoples.
Colonial (ca. A.D. 1700-1979)	• Island Caribs resist early European attempts to settle SVG. • Colonization of the island by Europeans begins in the late 18th-early 19th centuries. • A.D. 1783 Treaty of Versailles grants Britain control of SVG. • First Carib rebellion in 1772-1773; Second Carib rebellion 1795-1796; After second rebellion, majority of the Carib population deported • Development of a plantation economy throughout the 19th century focused on the production of sugar, cotton, coffee, and cocoa first using African slave labor until slavery abolished in 1834. • Collapse of sugar prices in the late 19th century combined with the hurricane of 1898 and an eruption of La Soufrière Volcano in 1902 devastate the economy and end the sugar industry.
Modern (A.D. 1979-Present)	• SVG becomes independent on Oct. 27, 1979, new government formed as a constitutional monarchy, and SVG becomes a member of the Commonwealth. • A.D. 1979 La Soufrière Volcano erupts, damaging agriculture and the tourist trade. • New Democratic Party, under James Mitchell, governs SVG from 1984-2000. • 2001 the Unity Labour Party wins electoral majority, and its leader, Ralph Gonsalves, becomes prime minister.

Source: Callaghan 2014; Fraser 2016; Rouse 1992

Cultural heritage resources dating to all of the periods described in Table 4-19 have been identified across SVG. Table 4-20 provides examples of SVG cultural heritage resources for each of cultural heritage resource types defined in the IDB Technical Note.

Table 4-20: Examples of Cultural Heritage Resources in SVG

IDB Technical Note Resources Types	Examples from SVG
Archaeological Sites	• Lot 14, Dandrade 1-3, Tourama 1, Orange Hill 1 prehistoric settlement/village sites • Big Gut Water Tank prehistoric burial site • 19th century Lasham Sugar Cane Mill ruins
Historic Architecture	• Fort Charlotte and Fort Murray • Black Point Tunnel and Byere Tunnel • Her Majesty's Prison in Kingstown • Cobblestone Inn and Cotton House • Lasham Sugar Cane Planation ruins • Orange Hill Aqueduct
Historic Landscapes	• 18 prehistoric petroglyph sites such as Layou on tentative list of UNESCO World Heritage Sites • 19th century Orange Hill Aqueduct and canals • 19th century sugar plantation landscapes
Living Heritage	• Anglican, Methodist, Catholic, Evangelical churches and ministry buildings • Modern community cemeteries

The desktop survey identified seven known prehistoric archaeological sites and one historic architectural feature within or immediately adjacent to the cultural heritage study area. The archaeological sites within the study area are the Dandrade 1, 2, and 3; Tourama 1; Orange Hill 1 and 2; and Lot 14 settlement/village sites. These sites date from the Saladoid (500 B.C. - A.D. 500) through Island Carib/Garufuna (A.D. 1400-ca. 1700) periods. A site known as "Lot 14" is typical of the type of site found in the area. The Lot 14 site was identified in a road cut bank and consisted of a subsurface midden deposit containing polychrome and zoned incised potsherds and ceramic griddles (Bullen and Bullen 1972).

The desktop study identified one example of this type of historic architecture in the cultural heritage study area: the Orange Hill Aqueduct. The Orange Hill Aqueduct is an arched, stone aqueduct built in the 19th century to provide water from inland rivers to a sugar mill located north of Orange Hill. The intact section of the aqueduct crosses the Windward Highway north of Orange Hill. The stone aqueduct was the terminus of a large, steel, and earthen canal that transported water from a dammed reservoir at Hell's Gate, a tributary of the Rabacca River. The canal crossed the Owia River and supplied water to the historic Lot 14 and Tourama sugar plantatoins before ending at the Orange Hill Aqueduct.

4.4.2 *Field Survey*

The cultural heritage field survey consisted of pedestrian within the cultural heritage study area and a windshield survey along the proposed Project route (i.e., Kingstown Port to the Project site via the Windward Highway). The pedestrian survey included two elements: 1) a systematic pedestrian survey of the well pad and injection well sites and 2) site reconnaissance surveys at previously identified archaeological sites.

4.4.2.1 Pedestrian Survey

The pedestrian survey of exploration drill pads W1 and W3 and the injection pads W1 and W3 did not identify any archaeological resources. Surface visibility was relatively poor at all sites as these areas are currently used as cattle pastures and for small vegetable gardens. The thick vegetation in these areas prevented the identification surface indicators of any archaeological resources that may be present. Exploration drill pad W1 is located in an active banana plantation where vegetation clearance and planting have created approximately 50 percent surface visibility; however, no archaeological resources were identified. In addition to vegetation, a layer of volcanic ash may cover any archaeological sites. Dr. Ronald Murray, a local biodiversity specialist, informed the survey team that the 1979 eruption of La Soufrière Volcano deposited up to 1 m of ash on the windward side of the volcano. These ash deposits may have buried any archaeological features that may have been visible on the ground surface.

4.4.2.2 Site Reconnaissance Survey

ERM conducted site reconnaissance surveys at four previously identified archaeological sites within the cultural heritage study area: Dandrade 2, Dandrade 3, Orange Hill 1, and Lot 14. Dr. Richard Callaghan from the University of Calgary provided the location, in the form of latitude and longitude, of each site (Personal Communication 2016). These sites consisted of prehistoric artifact scatters dated to the Saladoid Period (500 B.C. - A.D. 500). The results of the site reconnaissance surveys are summarized in Table 4-21, and the location of each site is shown in Figure 4-50. Due to poor surface visibility, no archaeological artifacts or features were observed at any of the sites visited during the reconnaissance surveys (Figure 4-51 and Figure 4-52).

Table 4-21: Archaeological Sites Visited during Site Reconnaissance Surveys

Site	Characteristics
Dandrade 2	Prehistoric archaeological site originally identified by Dr. Callaghan in 2014. Site is located on or along the margins of a narrow ridge spur bound to the north and south by steep walled, narrow drainages 20 m deep or more. Likely identified within plowed agricultural field or on the eroding shoulders of the ridge.
Orange Hill 1	Site originally identified during survey performed by Dr. Callaghan in 2014. Global Positioning System coordinate provided by Dr. Callaghan places the site on the edge of a ridge along the W3 feeder road. Construction of the road created a roughly 2-meter-high road cut on the south side of the road. It appears road construction cut through the center of the natural east-west running ridge. It is likely that Orange Hill 1 was identified in this road cut as it represents the only visible soil exposures in the area.
Orange Hill 2	Prehistoric site originally identified by Dr. Callaghan in 2014. Site coordinate provided by Dr. Callaghan places the site in an active banana plantation within the footslope and toeslope of a gently rising hill. Area covered in low grass resulting in poor surface visibility. Only exception was at the base of newly planted banana trees. Visually inspected the backdirt piles from 10 recently planted trees but did not identify any archaeological materials.
Lot 14	Site originally identified by a Sgt. Murphy in 1970. He described an Amerindian site exposed by erosion in the western part of an area known as Lot 14 on the northern side of the road leading from the shore towards La Soufrière Volcano at the point where the road approaches closest to the south side of the Waribishy River (Bullen and Bullen 1972). Location provided by Dr. Callaghan places the site further to the south, on a road running on the north side of the Rabacca River.

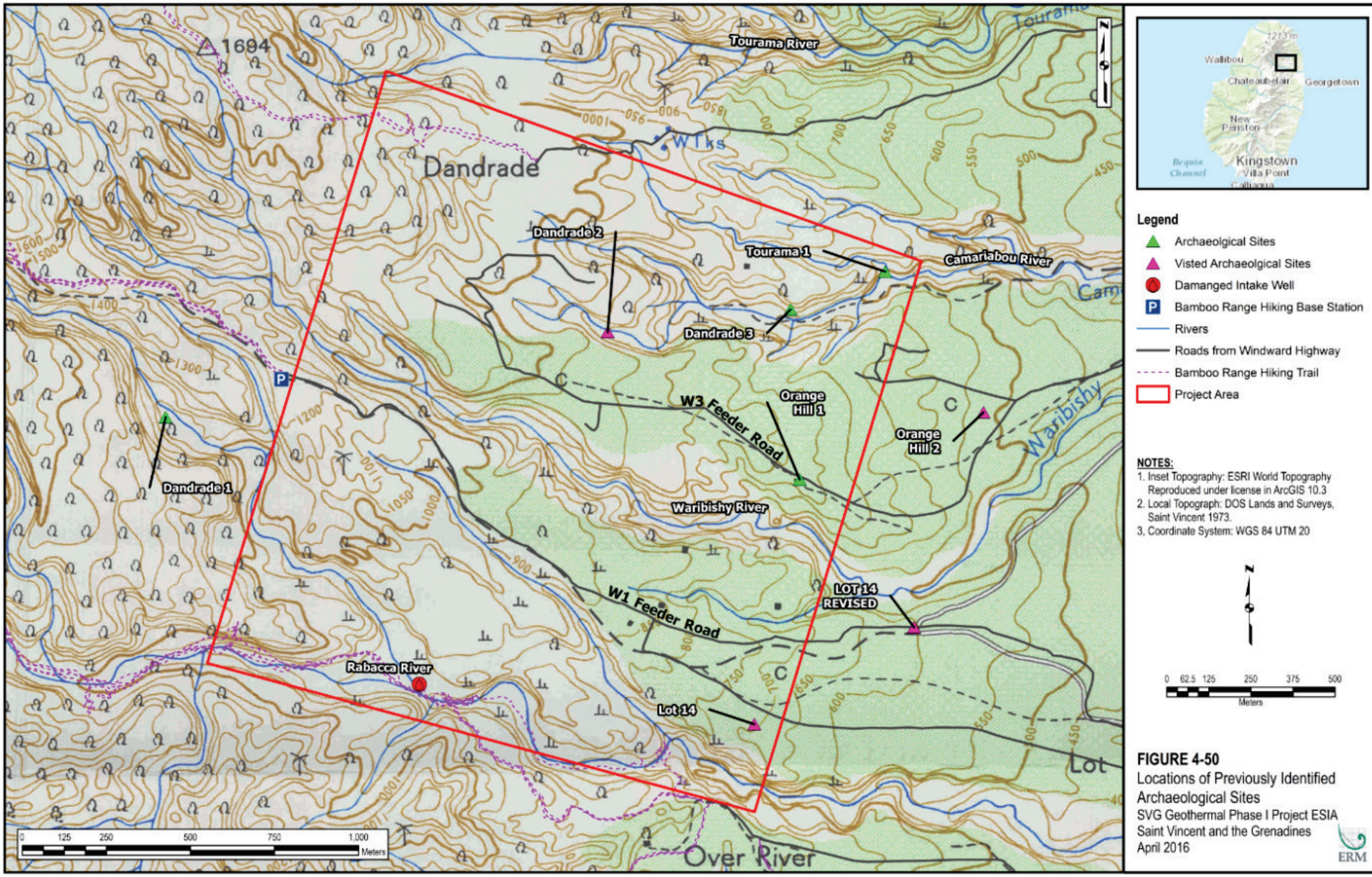


Figure 4-50: Locations of Previously Identified Archaeological Sites

Figure 4-51: Orange Hill 1 Road Cut

Figure 4-52: Orange Hill 2

Based on the locations provided by Dr. Callaghan, sites Orange Hill 1 and Orange Hill 2 are located along the W3 feeder road. Due to the lack of surface visibility and no obvious signs of recent agricultural or other ground disturbing activity, Orange Hill 1 was likely exposed during construction of the existing access road. Intact portions of the site may be present to the north and/or south of the current access road. The location provided for Orange Hill 2 is approximately 50 m from the existing access road. However, without additional information on the size and boundaries of the site, it is possible the site extends to the north side of the roadway.

During the site reconnaissance it was determined that the location of Lot 14 provided by Dr. Callaghan did not match the original site description given by Sgt. Murphy in 1970. Through a comparison of topographic maps of the cultural heritage study area, the description provided by Sgt. Murphy, and onsite conditions it was determined that site Lot 14 is located along feeder road1. Sgt. Murphy's description of the site' location "in the western part of an area known as Lot 14 on the northern side of the road leading from the shore towards Mt. Soufrière at the point where the road approaches closest to the south side of the Waribishy River" (Bullen and Bullen 1972). The description suggests the site is located along feeder road W1, approximately 1.5 km east of the exploration drill pad location.

4.4.2.3 *Windshield Survey*

An ERM cultural heritage specialist traveling from Kingstown to the Project Area along the Windward Highway and the W1 and W3 feeder roads performed the windshield survey. During the survey, the specialist stopped at cultural heritage sites that were observed along the route and recorded the resource location, characteristics, and photographed the resources. Based on local conditions such as road width and topography, it was determined that resources within 50 m of the road could be subject to impacts from the Project's use of the roadway.

The windshield survey identified 13 cultural heritage resources within 50 m of the Windward Highway. The location of each resource is presented in Figure 4-53. Table 4-22 provides summary information about each resource; and examples of the resources are provided in Figure 4-54 through Figure 4-58.

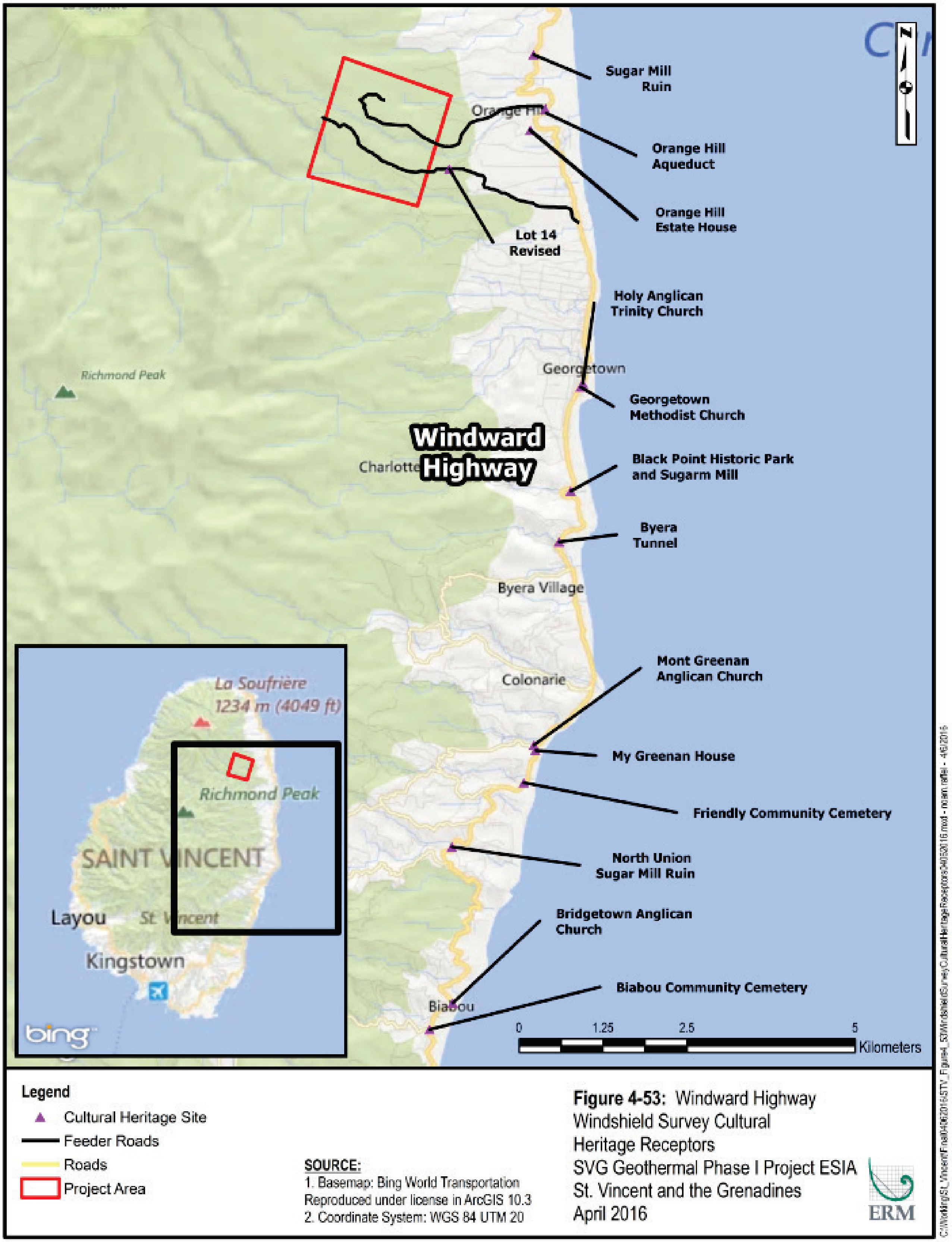


Figure 4-53: Windshield Survey Cultural Heritage Receptors

Table 4-22: Cultural Heritage Resources Identified during Windshield Survey

Receptor	Description
Holy Trinity Anglican Church	19th Century stone church, cemetery, and rectory ruin along the road in Georgetown. Church built in 1829 (Gordon and Hersh 2005). Church and cemetery still used by local population. SVG NT stated resource eligible for listing on NRHB.
Georgetown Methodist Church	Early 20th Century stone church and 19th century cemetery along the road in Georgetown. Church built in 1903 after original church destroyed by hurricane in 1898 (Gordon and Hersh 2005). Church and cemetery still used by local population. SVG NT stated resource eligible for listing on NRHB.
Mount Greenan Anglican Church	19th century stone church and cemetery on small hill overlooking roadway. Church and cemetery still used by local population. SVG NT stated resource eligible for listing on NRHB.
Mount Greenan House	19th century stone estate house and associated outbuildings. House is in good condition and currently occupied. SVG NT stated resource eligible for listing on NRHB.
Orange Hill Aqueduct and Sugar Mill Ruin	19th century aqueduct crossing over roadway near feeder road W3. Sugar mill ruin being redeveloped into an arrowroot processing facility as part of Youroumei Heritage Village project. SVG NT stated the resource is listed on the NRHB.
Byera Tunnel	Early 19th century historic tunnel renovated with concrete and steel in 2004. Resource listed on the NRHB.
Black Point Historic Park	Recreation area around 19th century sugar storage tunnel. Tunnel excavated using slave labor. Resource listed on the NRHB.
North Union Sugar Mill Ruin	Well known, large, two-story, stone sugar mill ruin along roadway. Resource part of planned island-wide sugar mill ruin interpretive program under development by SVG NT.
Orange Hill Estate House	19th century estate house located west of Orange Hill within the grounds of the Horticulture Research and Development campus (Gordon and Hersh 2005).
Friendly Community Cemetery	Modern community cemetery containing over 100 graves on west side of roadway. Local community maintains and uses cemetery.
Biabou Community Cemetery	Modern community cemetery containing over 100 graves on east side of roadway. Local community maintains and uses cemetery.
Black Point Sugar Mill Ruin	Sugar mill ruin consisting of two stone building foundations outside the Black Point Recreation area. Resource part of planned island wide sugar mill ruin interpretive program under development by SVG NT.
Bridgetown Anglican Church	Small, 19th century stone Anglican Church on east side of road. Still used by local community for religious services. SVG NT stated resource eligible for listing on NRHB.

NRHB = National Register of Historic Buildings; SVG NT = SVG National Trust

Figure 4-54: 19th Century Methodist (Top) and Anglican (Bottom) Churches in Georgetown

Figure 4-55: North Union Sugar Mill Ruin

Figure 4-56: Community Cemetery along Edge of a Coastal Road

Figure 4-57: Orange Hill Aqueduct

Figure 4-58: Rabacca Estate House

A number of the resources identified during the windshield survey were discussed during consultations with the SVG National Trust (NT). The SVG NT stated that although the majority of the resources identified along the proposed route is not listed on the NRHB, the SVG NT considered them eligible for inclusion on the register. In order to prevent impacts that could affect the eligibility of resources for future listing on the NRHB, the SVG NT stated that these resources should be treated as if they were registered and subject to the attendant government protections under SVG law.

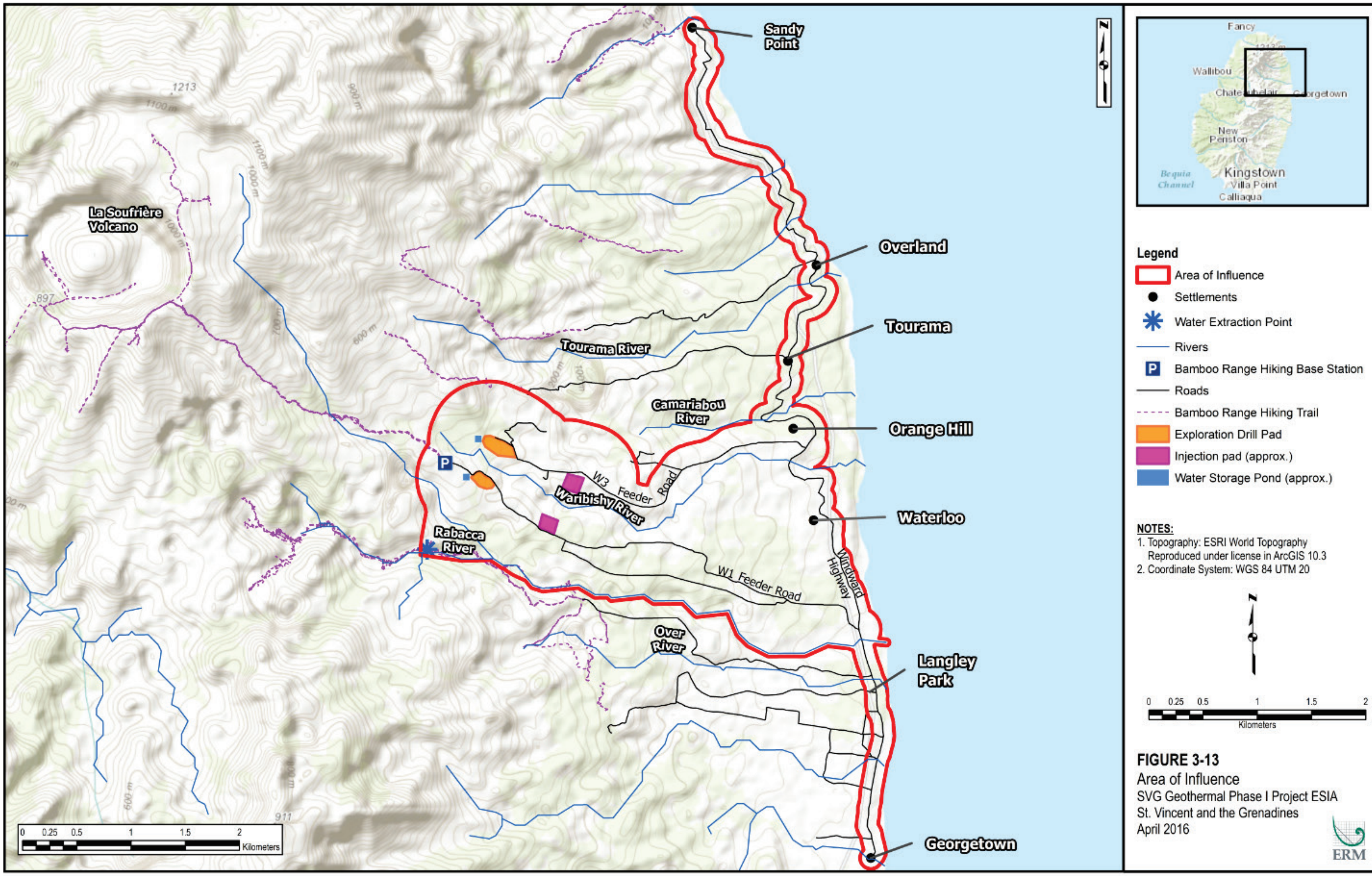


Figure 3-13: Project Area of Influence

5.0 IMPACT ASSESSMENT

5.1 GENERAL METHODOLOGY

The primary purpose of an Environmental and Social Impact Assessment (ESIA) is to predict the impacts resulting from the proposed project. Impacts can be direct, indirect, or induced, as defined in Table 5-1.

Table 5-1: Impact Designation Definitions

Designation	Definition
Direct	Impacts that result from a direct interaction between the Project and a resource/receptor (e.g., between disturbance of a plot of land and the habitats on that plot of land that are affected).
Indirect	Impacts that follow from the direct interactions between the Project and its environment as a result of subsequent interactions within the environment (e.g., viability of a species population resulting from loss of part of a habitat as a result of the Project occupying a plot of land).
Induced	Impacts that result from other activities (which are not part of the Project) that happen as a consequence of the Project (e.g., influx of camp followers resulting from the presence of a large Project workforce).

The assessment of impacts proceeds through an iterative process that considers four questions as illustrated in Figure 5-1.

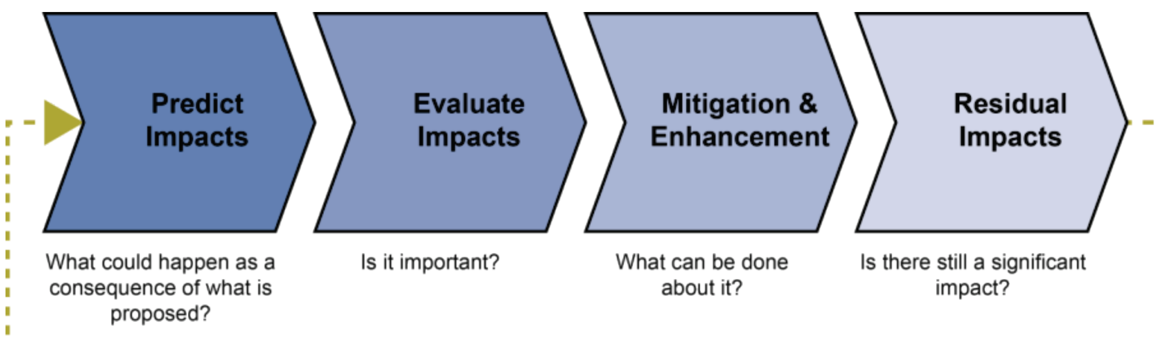


Figure 5-1: Impact Prediction and Evaluation Process

These questions are expanded in Steps 1 through 4 below.

Step 1: Predict Impacts

An ESIA evaluates potential project impacts by predicting and quantifying to the extent possible the magnitude of impacts on resources (e.g., water and air) or receptors (e.g., people, communities, wildlife species, habitats). Magnitude is a function of the following impact characteristics:

- Type of impact (i.e., direct, indirect, induced);
- Nature of the change (what is affected and how);
- Size, scale, or intensity;

- Geographical extent and distribution (e.g., local, regional, international); and
- Duration and/or frequency (e.g., temporary, short term, long term, permanent).

Magnitude describes the actual change that is predicted to occur in the resource or receptor. The magnitude of an impact takes into account all the various dimensions of a particular impact in order to make a determination as to where the impact falls on the spectrum (in the case of adverse impacts) from *Negligible* to *Large*. Some impacts can result in changes to the environment that may be immeasurable, undetectable, or within the range of normal natural variation. Such changes can be regarded as essentially having no impact, and are thus characterized as having a *Negligible* magnitude. In determining the magnitude of impacts on resources and receptors, embedded controls (i.e., physical or procedural controls that are planned as part of the project design) are taken into consideration (e.g., the magnitude of impacts on stream water quality from construction take into consideration the effectiveness of proposed sediment and erosion control measures).

In addition to characterizing the magnitude of impact, the sensitivity/vulnerability/importance of the impacted resource/receptor is characterized. There is a range of factors taken into account when defining the sensitivity/vulnerability/importance of the resource/receptor. Where the resource is physical (e.g., a waterbody), its sensitivity (to change) and importance (on a local, national, and international scale) are considered. Where the resource/receptor is biological or cultural (e.g., the marine environment or a coral reef), its importance (e.g., its local, regional, national, or international importance) and its sensitivity to the specific type of impact are considered. Where the receptor is human, the vulnerability of the individual, community, or wider societal group is considered. Other factors may also be considered when characterizing sensitivity/vulnerability/importance, such as legal protection, government policy, stakeholder views, and economic value.

As in the case of magnitude, the sensitivity/vulnerability/importance designations themselves are universally consistent (i.e., *Low*, *Medium*, and *High*), but the definitions for these designations would vary on a resource/receptor basis.

Step 2: Evaluate Impacts

An ESIA evaluates the significance of a potential project impact by considering, in combination, the magnitude of the impact and the sensitivity/vulnerability/importance of the impacted resource or receptor. The assignment of a significance rating facilitates decision-makers and stakeholders to understand how much weight should be given to the issue in their process. In the case of positive impacts, the significance is assigned as *Positive*.

Significance was assigned for each impact using the matrix shown in Table 5-2. This matrix applies universally to all resources/receptors.

Table 5-2: Evaluation of Significance of Impacts

Impact Significance Matrix		**Sensitivity/Vulnerability/Importance of Resource/Receptor**		
		Low	**Medium**	**High**
Negative Impacts				
Magnitude of Impact	Negligible	Negligible	Negligible	Negligible
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Major
Positive Impacts				
Magnitude of Impact	NA	Positive	Positive	Positive

In terms of what the various significance designations represent, the following considerations are provided:

- An impact of *Negligible* significance is one where a resource/receptor (including people) would not be affected by a particular activity, or the predicted effect is deemed to be imperceptible or is indistinguishable from natural background variations.
- An impact of *Minor* significance is one where a resource/receptor would experience a noticeable effect, but the impact magnitude is sufficiently *Small* (with or without mitigation) and/or the resource/receptor is of *Low* sensitivity/vulnerability/importance. In either case, the magnitude should be well within applicable standards.
- An impact of *Moderate* significance has an impact magnitude that is within applicable standards but falls somewhere in the range from a threshold below which the impact is *Minor*, up to a level that might be just short of breaching a legal limit. To design an activity so that its effects only just avoid breaking a law and/or cause a major impact is not best practice. The emphasis for *Moderate* impacts is therefore on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable. This does not necessarily mean that impacts of *Moderate* significance have to be reduced to *Minor*, but rather that *Moderate* impacts are being managed effectively and efficiently.
- An impact of *Major* significance is one where an accepted limit or standard may be exceeded, or *Large* magnitude impacts occur to highly valued/sensitive resources/receptors.
- An impact of *Positive* significance is one that has been identified as having a positive effect on the receptor/resource. Generally, this ESIA does not attempt to characterize magnitude for positive impacts.

A goal of an impact assessment is to get to a position where a project does not have any *Major* residual impacts (i.e., after mitigation measures are considered), certainly not ones that would endure into the long term or extend over a large area. However, for some aspects, there may be *Major* residual impacts after all practicable mitigation options have been exhausted. An example might be the visual impact of a facility. It is then the function of the decision-makers and stakeholders to weigh such negative factors against the positive ones, such as employment, in coming to a decision on a project.

Step 3: Mitigation and Enhancement

An ESIA process aims to ensure that project decisions are made in full knowledge of their likely impacts on the environment and society. A vital step within the process for this ESIA was therefore the identification of measures that could be taken to mitigate potential impacts of the St. Vincent Geothermal Project Phase I Exploration (the Project).

The process involved identifying where potentially significant impacts could occur and identifying ways of mitigating those impacts as far as reasonably possible. A mitigation hierarchy was used in which preference is always given to trying to avoid or minimize the impact before considering other types of mitigation (i.e., remedy, compensate, offset). The conventional preferred hierarchy of measures, which was followed in this ESIA, is provided below:

- Avoid —remove the source of the impact;
- Minimize —reduce the magnitude of the impact;
- Mitigate—"repair" the results of the impact after it has occurred; and
- Compensate/offset—address the loss or change to a resource by replacing the loss/change in kind or with a different resource of equal value.

Step 4: Residual Impacts

Once mitigation measures are agreed to, the next step in the impact assessment process is to determine the residual impact significance. Residual impacts are the impacts that are predicted to remain after both embedded controls and committed mitigation has been taken into consideration. In most cases, the sensitivity/vulnerability/importance of a receptor is unaffected by proposed mitigation measures; the mitigation measure is typically intended to reduce the magnitude of a predicted impact, thereby reducing its overall significance.

5.2 PHYSICAL RESOURCES IMPACT ASSESSMENT

5.2.1 Air Quality

5.2.1.1 Introduction

This section presents an assessment of the Project impacts on air quality. The presence and concentration of potential air pollutants may vary depending on the characteristics of the geothermal resources. During well drilling and testing, impacts on air quality are primarily caused by hydrogen sulfide (H_2S) emissions. Other emission sources such as dust on roadways are expected to be insignificant. Carbon dioxide is also in the steam vented out during blow testing, although its emissions are considered *Negligible* compared to fossil fuel combustion sources (*IFC EHS Guidelines for Geothermal Power Generation, April 2007*). The following sections discuss the assessment methodology, identification of air quality receptors, potential air emissions from Project activities, determination of impact significance, description of mitigation measures, and determination of residual impact significance during the exploratory activities.

5.2.1.2 *Assessment Methodology*

Impacts on air quality are typically evaluated by reference to numerical standards for air quality and dust deposition. The Project is not a major source of dust; therefore, dust deposition is not discussed further. Air quality has been assessed following a standard methodology shown in Figure 5-2.

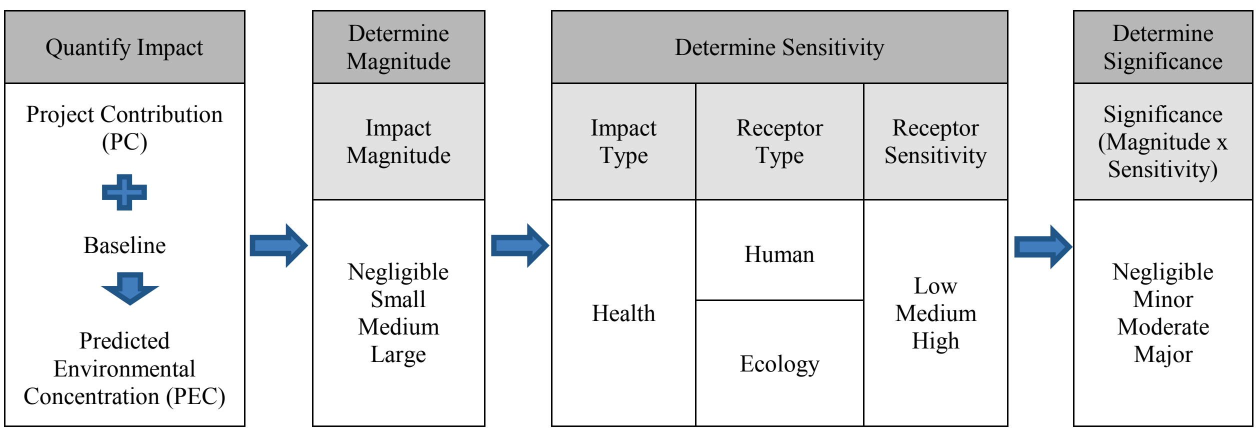


Figure 5-2: Air Quality Impact Assessment Process Flowchart

The approach combines impact magnitude with receptor sensitivity to determine impact significance.

The following subsections describe the magnitude and sensitivity approach (as shown on Figure 5-2) used for evaluating impacts of airborne pollutant H_2S on human (health hazard and odor nuisance) and ecological receptors (plant growth).

5.2.1.3 *Potential Air Emission Sources from Project Activities*

The main activity that would emit H_2S air emissions is steam blow testing. Because non-condensable geothermal gases, including H_2S, are heavier than air, the gases can accumulate in confined spaces and low-lying areas. Steam blow testing would occur for 1 to 3 months after drilling of the exploratory drill pads. Silencers and wellhead valves would be installed during blow testing. This assessment assumes steam blow testing would occur continuously 24-hours per day.

5.2.1.4 *Identification of Receptors*

There are settlements located northeast (e.g., Tourama) and east (e.g., Orange Hill and Waterloo) of the exploration drill pads and injection pads (see Figure 4-45 in Section 4.3*, Socioeconomic and Health Baseline*). Impacts on ecological receptors (such as plants and animals) within the Project area are discussed in Section 5.3, *Biodiversity Impact Assessment*.

5.2.1.5 *Magnitude of Impact*

The International Finance Corporation (IFC) method of determining the magnitude of air quality impacts is based on two factors:

- The increase in pollutant concentrations in air as a result of the project based on detailed air dispersion modeling (Project Contribution [PC] or incremental impact); and
- The total air pollutant concentrations arising as a result of the existing baseline added to the PC (the Predicted Environmental Concentration [PEC], or cumulative impact).

This method requires project emissions quantification, air dispersion modeling, and baseline air quality data. These analyses were not performed for this Project given the lack of available baseline air quality data and Project emissions quantification. There was also insufficient publicly available wind statistics data (hourly wind speed and direction) to generate a wind rose for the Project (although we recommend the establishment of a meteorological station near Site W1 so that site specific data would be available for Phase II modeling). Therefore, a qualitative approach was used to determine the magnitude of air quality impacts. The qualitative determination of impact magnitude for air quality is based on the following significance criteria:

Extent of Impact: Most of the nearby settlements are located several kilometers from the Project site. H_2S is a dense gas, which tends to settle down quickly, and as such is not likely to disperse too far from its source. For example, under normal temperature and pressure (20˚C and 1 atmosphere of pressure), the densities of H_2S and air are 1.434 and 1.205 kg/m3, respectively (The Engineering ToolBox 2016). As H_2S would not disperse too far (i.e. localized), the extent of it impact is categorized as *Small*.

Duration of Impact: This impact only occurs during the production blow tests, which takes place for 1 to 3 month at each exploration well. Based on the short duration of impact, this criterion is categorized as *Small*.

Intensity of Impact: Considering the potential exposure of onsite workers, nearby settlements, and ecological receptors to H_2S concentrations from exploratory activities, the intensity of impact is categorized as *Medium*.

Reversibility of Impacts: H_2S emissions would be dispersed in ambient air, and its concentration would be decreased when the construction/exploratory stage is completed. Based on the reversibility of impacts, this criterion is categorized as *Small*.

The overall magnitude of air quality impacts is categorized as *Small* to *Medium*.

5.2.1.6 *Sensitivity of Receptors*

The sensitivity of receptors is determined based upon the nature of the receptor and the nature of the impact. The approach in this assessment assumes that the sensitivity for human health within the general population is *Medium*. As air quality standards are set to protect the most vulnerable individuals in society, there is inherently a margin of safety within them. There are a small number of specific cases where the sensitivity may be defined as *High*; these include where there are particularly vulnerable individuals (e.g., a hospital where there are intensive care wards and high dependency wards where patients are particularly sensitive to air pollution). For the purpose of this assessment, the sensitivity for human receptors is set at *Medium*.

For vegetation (an ecological resource), the sensitivity is defined on the basis of its designated importance as an ecological resource. As for human health, this assessment designates the importance of vegetation (e.g., various plant species, agricultural crops) within the Project area as *Medium.* Details on the types of plant species and agricultural crops near the Project area are provided in Section 5.3, *Biodiversity Impact Assessment*.

Therefore, combining a *Small* to *Medium* magnitude with a *Medium* sensitivity would result in an overall *Minor* to *Moderate* impact significance.

5.2.1.7 *Mitigation Measures*

To avoid or reduce the environmental/offsite and occupational exposure to geothermal gases (mainly H_2S that may cause health hazards and odor nuisance) during exploratory activities, the following mitigation measures are recommended (aside from air pollution controls incorporated into Project design such as injection of non-condensable gases with geothermal fluids):

- Install an H_2S gas-monitoring network, taking into account the location of emissions sources and areas of community use and habitation. Operate the H_2S gas monitoring system continuously to facilitate early detection and warning.
- If necessary, use abatement systems to remove H_2S emissions from non-condensable gases. Examples of H_2S controls include wet or dry scrubber systems or a liquid phase/oxidation system.
- Provide adequate ventilation of nearby low-lying occupied buildings to avoid H_2S accumulation.

- Provide workers with educational materials, training, and Personal Protective Equipment (PPE) to protect them from H_2S emissions.
- If H_2S monitoring identifies an offsite human health risk, then relocate nearby receptors (i.e., community members) could be affected by H_2S emissions.

5.2.1.8 *Residual Impact (Post-mitigation)*

The implementation of the above mitigation measures should reduce the H_2S concentrations onsite (worker exposure) and offsite (nearby communities) to acceptable levels and, as such, should reduce probable *Minor* to *Moderate* air quality impacts to *Minor*.

5.2.1.9 *Air Quality Impact Summary*

The impact significance of increases in H_2S concentrations during the Project activities would range from *Minor* to *Moderate* due to the *Small* to *Medium* air quality impact magnitude and a *Medium* sensitivity for human and ecological receptors.

Table 5-3 provides a summary of potential impacts to air quality resources or receptors and includes mitigation measures that would avoid or minimize the potential impacts. Specific impact significance ratings pre-mitigation and post-mitigation (i.e., residual significance) are also provided in the table. Overall, impacts associated with air quality range from *Minor* to *Moderate* under pre-mitigation conditions and *Minor* under post-mitigation conditions. The residual impacts would not pose a risk to surrounding communities provided the recommended mitigation measures are implemented.

Table 5-3: Summary of Potential Air Quality Impacts and Recommended Mitigation Measures

Resource/ Receptor - Impact	Sensitivity	Magnitude	Pre Mitigation Significance	Mitigation Measures	Residual Significance
Human settlements - Potential increase in H_2S concentrations (health hazard, odor nuisance)	Medium	Small to Medium	Minor to Moderate	• Use abatement systems to remove H2S emissions from non-condensable gases. • Install an H2S gas-monitoring network, taking into account the location of emissions sources and areas of community use and habitation. • Provide adequate ventilation of nearby low-lying occupied buildings to avoid H2S accumulation. • Provide workers with	Minor

Resource/ Receptor - Impact	Sensitivity	Magnitude	Pre Mitigation Significance	Mitigation Measures	Residual Significance
				educational materials, training, and PPE. • If H_2S monitoring identifies an offsite human health risk, then relocate nearby receptors (i.e., community members) that could be affected by H^2S emissions.	

5.2.2 *Noise*

5.2.2.1 *Introduction*

This section presents an assessment of the Project impacts on the acoustic environment. The assessment methodology for noise, including standards and guidelines, prediction methodology, major noise activities, and impacts at closest receptor locations, is discussed in the following sections. Descriptions of receptor-specific impacts, impact significances, applicable mitigation measures, and residual significances during the construction and operation phases are also discussed.

5.2.2.2 *Assessment Methodology*

For most environmental impact topics/resources, an approach that combines impact magnitude with resource/receptor sensitivity is used to determine impact significance. This approach allows the use of a significance matrix that combines resource/receptor sensitivity with impact magnitude (as described in Section 5.1).

For noise, however, it is usually possible to predict noise levels quantitatively and compare them against standards that are resource-/receptor-specific and inherently take into account resource/receptor sensitivity. Furthermore, many numerical noise standards are noise source-specific (e.g., industrial noise is different from aircraft noise), some refer to baseline levels (i.e., allowable increases above baseline), and there can be a number of other factors that are relevant to determining impact significance. Thus, impact significance for noise is not determined using a magnitude versus sensitivity matrix, but is instead determined by comparison with accepted standards using the process outlined in Figure 5-3.

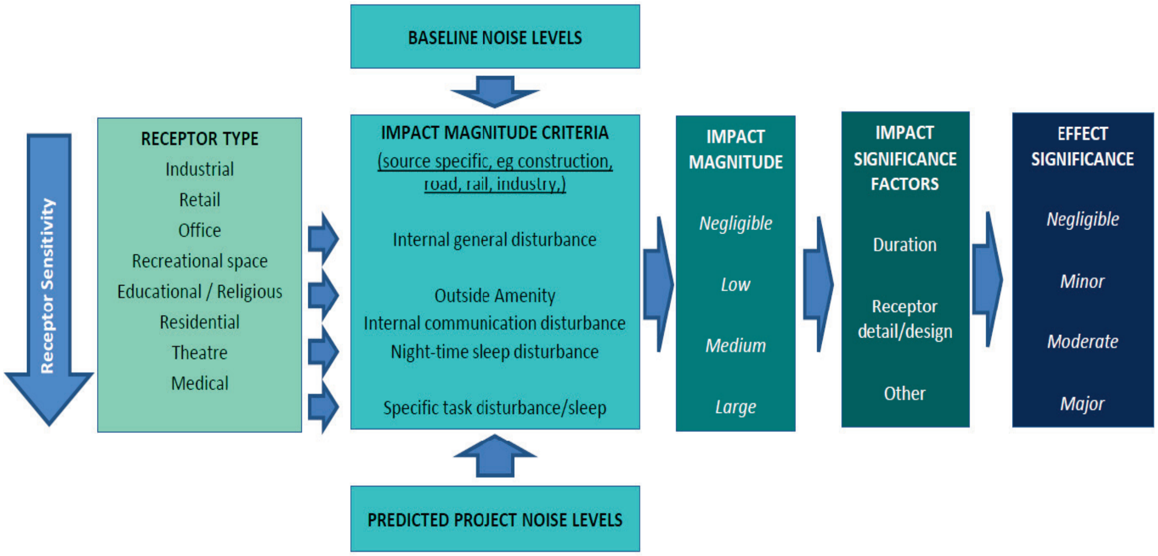


Figure 5-3: Noise Impact Assessment Process

Rather than applying a two-dimensional matrix for noise impact significance, the process for noise considers the type of receptor, draws on relevant standards or guidance to determine impact magnitude, and then considers other factors to determine significance.

There are no national noise standards in St. Vincent and the Grenadines (SVG)[viii]; therefore, the IFC limits for ambient/ airborne noise levels (IFC 2007) were used in this assessment as the basis of 'significance thresholds' (see Table 5-4).

Table 5-4: IFC Guidelines for Ambient Noise

Receptor	Maximum Ambient Noise Level, $L_{eq,\,1\,hour}$ (dBA)	
	Daytime (07:00-22:00)	Nighttime (22:00-07:00)
Residential, Institutional, Educational	55	45
Industrial, Commercial	70	70

Source: IFC 2007

L_{eq}, 1 hour = statistical noise descriptor that represents the equivalent continuous sound pressure level over a 1-hour period; dBA = A-weighted decibel

In environments where the ambient noise levels already exceed 55 dBA daytime and/or 45 dBA nighttime, the IFC indicates that additional noise emissions should not cause the ambient noise level in a residential area to rise by more than 3 dBA. The IFC criteria are also relevant to long-term noise sources, and they

[viii] SVG Noise Control Act of 1988 does not include numerical noise limits that apply to the proposed Project; the Act mainly discuses noise abatement and prohibition of nuisance (e.g., operation of loud speakers and musical instruments), and penalties for violators of the Act.

represent very stringent assessment criteria for temporary activities such as construction and seismic survey work.

The IFC guidance summarized above has been reviewed to establish a suitable set of criteria for the proposed Project; Table 5-5 applies to construction noise based on these standards. The duration of construction noise is accounted for by applying variable noise thresholds for significant impact.

Table 5-5: Noise Magnitude Criteria for Construction Activities in Residential Areas

Construction Period	**Daytime Noise Levels $L_{eq,\ 1hour}$ (dBA)**				**Nighttime Noise Levels $L_{eq,1hour}$ (dBA)**			
Magnitude Rating	**Negligible**	**Small**	**Medium**	**Large**	**Negligible**	**Small**	**Medium**	**Large**
Short term exposure <1 month	<70	70-75	>75-80	>80	<55	55-60	>60-65	>65
Medium term exposure 1-6 months	<65	65-70	>70-75	>75	<45	45-55	>55-60	>60
Long term exposure > 6 months	<55	55-60	>60-65	>65	<45	45-50	>50-55	>55

$L_{eq,}$ 1 hour = statistical noise descriptor that represents the equivalent continuous sound pressure level over a 1-hour period; dBA = A-weighted decibel; < = less than; > = greater than.

For airborne noise assessments, once impact magnitude is established, it is a straight conversion to impact significance, considering duration and receptor detail (see Table 5-6).

Table 5-6: Determination of Airborne Noise Impact Significance

Impact Magnitude Classification	**Impact Significance Factors[a]**	**Impact Significance Rating**
Negligible	Consider other influencing factors if necessary (e.g., duration, sound character)	Negligible
Small		Minor
Medium		Moderate
Large		Major

[a] Examples of factors that may influence significance, beyond that taken into account in the guidelines used to assess impact magnitude, include:

- **Duration of Impact** – For example, a noise source may operate on an intermittent or repetitive basis for only part of a day or nighttime period, or on a limited number of days per week, or only during daytime, such that it may be appropriate to downgrade the significance rating.
- **Character of Noise** – Noise of a particularly distinctive character (tonal or impulsive) may be more disturbing than a broadband noise, so it may be appropriate to upgrade the impact significance.
- **Receptor Detail or Design** – Guidelines for noise assessment assumes receptors have openable windows to sensitive rooms overlooking the noise source. This may not always be the case, so that noise impacts on facades that have no windows to noise sensitive rooms (e.g., offices, bedrooms, living rooms) or have upgraded levels of sound insulation (with associated ventilation if necessary to keep windows closed) can often be downgraded.
- **Meteorological Conditions** – Regular occurrence of conditions (usually more than 30 percent of the time) that enhance noise propagation, such as prevailing light stable winds (less than 3 meters per second) and temperature inversions, may warrant upgrading the significance ratings.

5.2.2.3 *Major Airborne Noise Activities*

The main activities that could result in potential noise increase are as follows:

- Drilling of the W1 and W3 exploration drill pads and injection pads; and
- Steam blow testing of exploration well.

Drilling activities at W1 and W3 exploration drill pads and injection pads would occur in sequence (i.e., drill rig installation and drilling), starting with W1; if blow testing does not result in favorable results, then moving onto W3. Drilling at each drill pad and injection pad would occur continuously for 2 to 6 months and consist of noise generating equipment such as a drill rig, generator, drilling mud mixing/separation facility, and mud pump. The drill rig would be a trailer-mounted hydraulic powered top-drive rig controlled by four hydraulic motors with diesel engines and a total brake horsepower of 1,500. Drilling operations would be carried out 24 hours per day. Steam blow testing would occur for 1 to 3 months per pad. Silencers and wellhead valves would be installed for blow testing. This assessment assumes steam blow testing would occur continuously 24 hours per day for at least 2 weeks.

It is important to note that the current assessment used the locations of the exploration and injection pads provided by SVGCL; if these locations change, the results of the qualitative assessment need to be updated.

Trucks would ship Project equipment from Kingston Port along the Windward Highway and through feeder roads to the drill site (approximately 33 kilometers [km] from the port to the drill site). However, truck traffic would be intermittent, likely occur during daytime hours, and would mostly occur only during the first stage of construction (i.e., up to 7 days). Therefore, noise impacts from these sources are not expected to be significant and were not quantified.

Similarly, heavy equipment associated with access road construction and drill site preparation would also generate some noise (i.e., bulldozer, graders, dump trucks, loaders, and cranes). However, noise from these sources would be intermittent, temporary, and likely occur only during daytime hours. Therefore, noise impacts from these sources are not expected to be significant and were not quantified.

5.2.2.4 *Construction Airborne Noise Prediction Methodology*

Sound power levels from drilling and steam blow testing were based on data from *Renewable and Sustainable Energy Reviews Journal - Review on life cycle environmental effects of geothermal power generation* (Bayer *et al.* 2013) and calculation methods described in *Acoustics – Attenuation of Sound During Propagation Outdoors, Part 2: General Method of Calculation. ISO 9613-2:1996* (ISO 1996) and Washington State Department of Transportation (WSDOT) *Advanced Training Manual, Biological Assessment Preparation for Transportation Projects,* Chapter 7*, Version 10-2015* (WSDOT 2015). The calculation method accounts for source sound power levels, distance from source to receptor, ground conditions at the site (hard or soft ground), and assumes downward wind propagation (i.e. conservatively assumes wind is blowing from source to receptor at all times). For point sources such as drilling and blow testing, the method assumes a 7.5 dBA reduction per doubling distance over soft ground such as those in the Project area (e.g., farmland, vegetation). This construction airborne noise prediction is a screening-level analysis and does not account for some attenuation measures such as atmospheric absorption (temperature and relative humidity), dense foliage/trees, and terrain (assumes flat topography) in the Project area. To account for such attenuation measures, a refined noise modelling analysis is required. However, the screening-level analysis is adequate for this Project and provides a conservative assessment as it excludes these possible noise attenuation measures.

5.2.2.5 Predicted Noise Levels at Closest Receptor Locations

Section 4.1.3, *Noise*, provides a description of the seven closest human receptors (N1 to N7) that Project activities are likely to impact. Noise impacts on ecological receptors such as wildlife within the Project area are discussed in Section 5.3, *Biodiversity Impact Assessment*. According to *IFC EHS for Geothermal Power Generation*, temporary noise levels may exceed 100 dBA during certain drilling and steam venting activities (IFC 2007). During well testing, high-pressure steam released through a silencer is generally in the range of 70 to 110 dBA, while high noise levels of around 120 dBA have been reported for drilling (Bayer *et al.* 2013). For the purpose of this assessment, sound power levels from drilling and steam blow testing (with a silencer installed in the steam vents as part of Project design) were conservatively assumed to be 120 dBA and 110 dBA, respectively. This is equivalent to maximum sound pressure levels of 112 dBA at 1 m for drilling (unmitigated) and 102 dBA at 1 m for steam blow testing with the silencer installed.

Predicted daytime and nighttime noise levels during exploratory drilling and steam blow testing are presented in Tables 5-7 and 5-8, respectively. Both tables also show the noise increase above ambient levels. Nighttime noise levels were not predicted for Receptors N3 and N5 (see Table 5-8) because both receptor locations are for daytime use only. Table 5-9 present the extent of Project-related airborne noise levels during exploratory drilling and steam blow testing. Table 5-9 also shows the magnitude of impacts on the closest receptor locations. Figures 5-4 to 5-9 provided approximate noise contours for drilling at exploration drill pads W1 and W3 and injection pads W1 and W3, as well as noise contours for steam blow testing at exploration drill pads W1 and W3.

Table 5-7: Predicted Daytime Noise Levels during Exploratory Drilling and Steam Blow Activities

Receptor ID	Closest Noise Sensitive Receptor	Measured Ambient Noise (dBA)	Nearest Project Noise Source(s) and Distances from Receptor	Predicted Project Noise Level Under Soft Ground Conditions (dBA)	Total Project + Ambient Noise (dBA)	Noise Increase Above Ambient Level (dB)
Daytime (07:00-22:00); IFC Limit = 55 dBA						
N1	Active mental health facility	56.8	Drilling at W3 RW: 2.0 km	29.5	56.8	0.0
			Steam blow testing at W3 RW: 2.0 km	19.5	56.8	0.0
N2	New Orange Hill Horticulture R & D facility; Community of New Orange Hill.	61.6	Drilling at W3 RW: 2.1 km	28.9	61.6	0.0
			Steam blow testing at W3 RW: 2.1 km	18.9	61.6	0.0
N3	Bamboo Range Visitor Center (daytime use only)	44.5	Drilling at W1: 247 m	52.2	52.9	8.4
			Steam blow testing at W1:247 m	42.2	46.5	2.0
N4	Farm worker building occupied by laborers	61.6	Drilling at W1: 60 m	67.5	68.5	6.9
			Steam blow testing at W1: 60 m	57.5	63.0	1.4
N5	Farmer laborer camp (daytime use only)	61.6	Drilling at W1 RW: <1 m	112.0	112.0	50.4
			Steam blow testing at W1 RW: <1 m	102.0	102.0	40.4
N6	Residential building currently under construction	61.6	Drilling at W3 RW: <1 m	112.0	112.0	50.4
			Steam blow testing at W3 RW: <1 m	102.0	102.0	40.4
N7	Banana processing structure used by plantation laborers	61.6	Drilling at W3: 88 m	63.4	65.6	4.0
			Steam blow testing at W3: 88 m	53.4	62.2	0.6

dB = decibel; dBA = A-weighted decibels; km = kilometer; m = meter; W1 = Exploration Well Pad 1; W3 = Exploration Well Pad 3; W1 RW = Injection Well Pad 3; W3 RW Injection Well Pad 3

Table 5-8: Predicted Nighttime Noise Levels during Exploratory Drilling and Steam Blow Activities

Receptor ID[1]	Closest Noise Sensitive Receptor	Measured Ambient Noise (dBA)	Nearest Project Noise Source(s) and Distances from Receptor	Predicted Project Noise Level Under Soft Ground Conditions (dBA)	Total Project + Ambient Noise (dBA)	Noise Increase Above Ambient Level (dB)
Night-time (22:00-07:00); IFC Limit = 45 dBA						
N1	Active mental health facility	57.1	Drilling at W3 RW: 2.0 km	29.5	57.1	0.0
			Steam blow testing at W3 RW: 2.0 km	19.5	57.1	0.0
N2	New Orange Hill Horticulture R & D facility; Community of New Orange Hill.	58.8	Drilling at W3 RW: 2.1 km	28.9	58.8	0.0
			Steam blow testing at W3 RW: 2.1 km	18.9	58.8	0.0
N4	Farm worker building occupied by laborers	43.7	Drilling at W 1: 60 m	67.5	67.6	23.9
			Steam blow testing at W1: 60 m	57.5	57.7	14.0
N6	Residential building currently under construction	48.3	Drilling at W 3 RW: <1 m	112.0	112.0	63.7
			Steam blow testing at W3 RW: <1 m	102.0	102.0	53.7
N7	Banana processing structure used by plantation laborers	45.4	Drilling at W3: 88 m	63.4	63.5	18.1
			Steam blow testing at W3: 88 m	53.4	54.0	8.6

dB = decibel; dBA = A-weighted decibels; km = kilometer; m = meter; W1 = Exploration Well Pad 1; W3 = Exploration Well Pad 3; W1 RW = Injection Well Pad 3; W3 RW Injection Well Pad 3

[1] Nighttime noise levels were not predicted for Receptors N3 (Bamboo Range Visitor Center) and N5 (Farmer laborer camp) because both receptor locations are for daytime use only.

Table 5-9: Extent of Project-related Airborne Noise Levels during Exploratory Drilling and Steam Blow Testing

Major Noise-related Activities	Distance to Various A-weighted Decibel Levels for Medium Term Exposure (>1 to 6 Months) from Exploratory Drilling Activities (meter)								
	Negligible Daytime and Nighttime Noise Distur-bance Threshold, 40 dBA	Negligible Daytime and Small Nighttime Noise Distur-bance Threshold, 45 dBA	Negligible Daytime and Small Nighttime Noise Distur-bance Threshold, 50 dBA	Negligible Daytime and Small Nighttime Noise Distur-bance Threshold, 55 dBA	Negligible Daytime and Medium Nighttime Noise Distur-bance Threshold, 60 dBA	Small Daytime and Large Nighttime Noise Distur-bance Threshold, 65 dBA	Small Daytime and Large Nighttime Noise Distur-bance Threshold, 70 dBA	Medium Daytime and Large Nighttime Noise Distur-bance Threshold, 75 dBA	Large Daytime and Large Nighttime Noise Distur-bance Threshold, 80 dBA
Drilling	759	479	302	191	120	76	48	30	19
Steam blow testing	302	191	120	76	48	30	19	12	8

> = greater than, dBA = A-weighted decibel

[a] Drilling and blow testing noise were modeled using the spherical loss model for point sources and assuming sound propagation over soft ground (mostly rural, agricultural, forested). Vehicle traffic noise were modeled using the cylindrical loss model for line sources and assuming sound propagation over soft ground (WSDOT 2015).

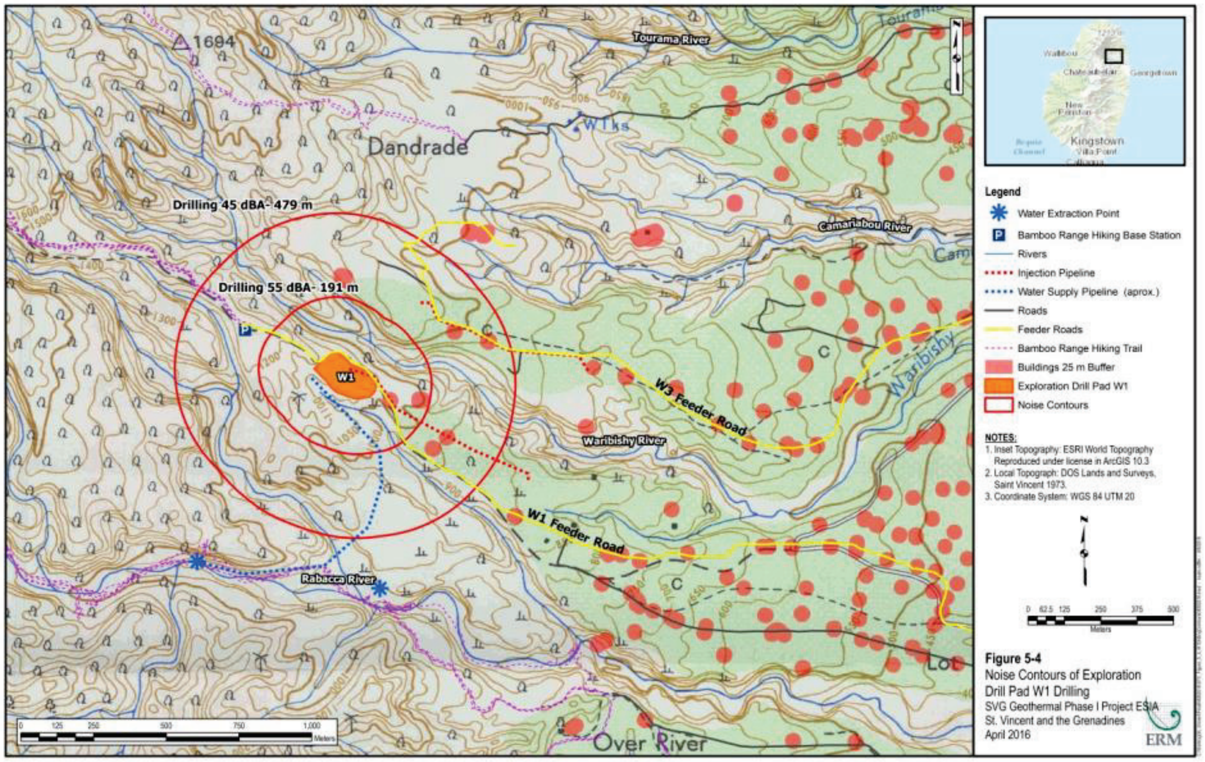


Figure 5-4: Noise Contours of Exploration Drill Pad W1 Drilling

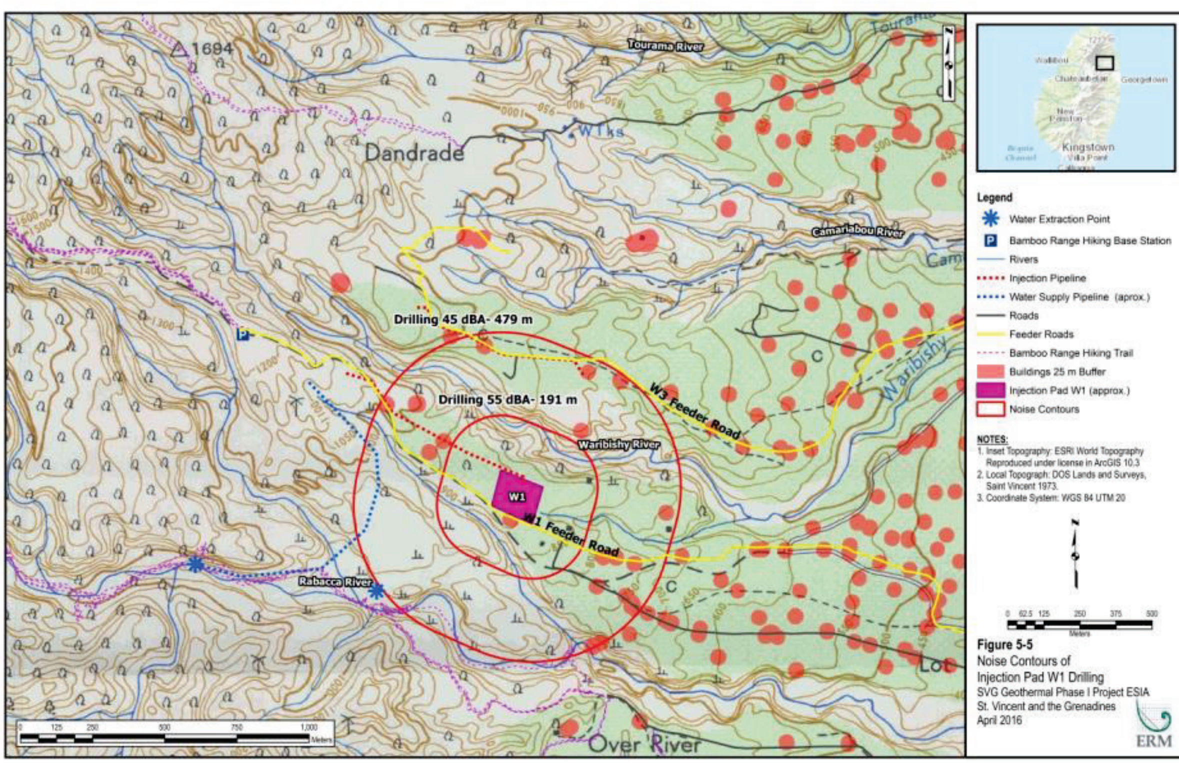


Figure 5-5: Noise Contours of Injection Pad W1 Drilling

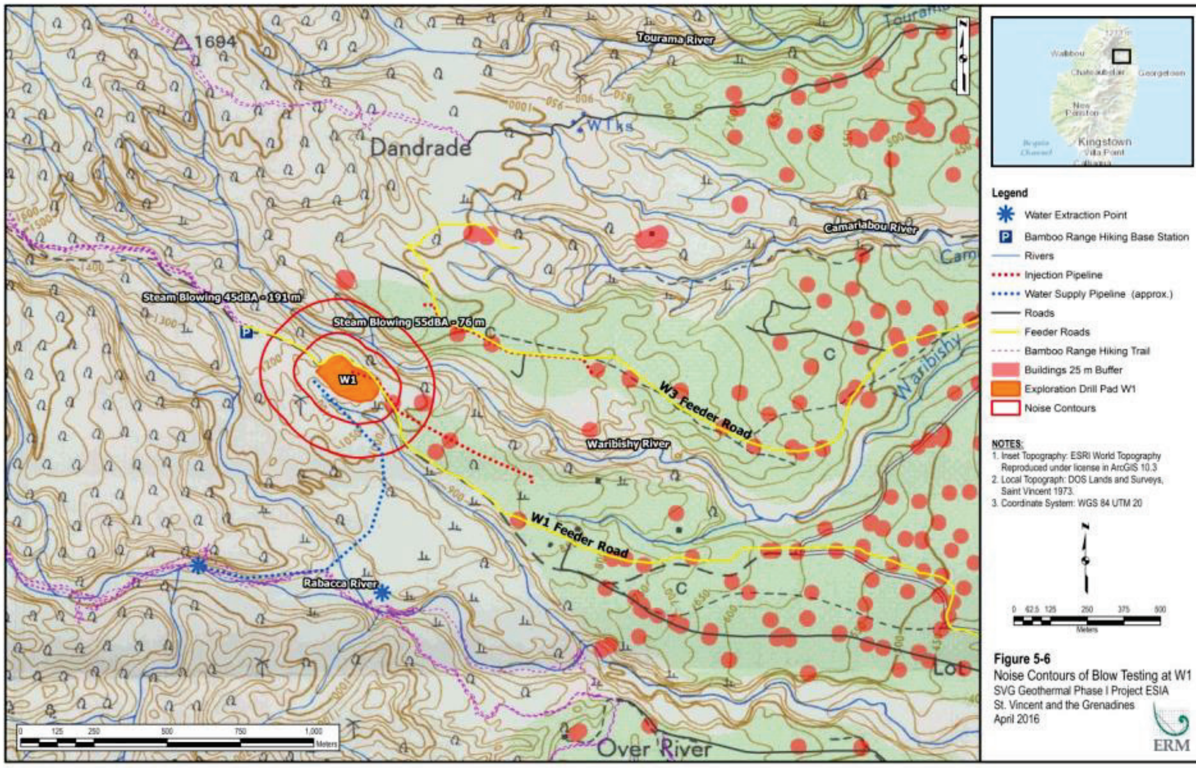


Figure 5-6: Noise Contours of Blow Testing at W1

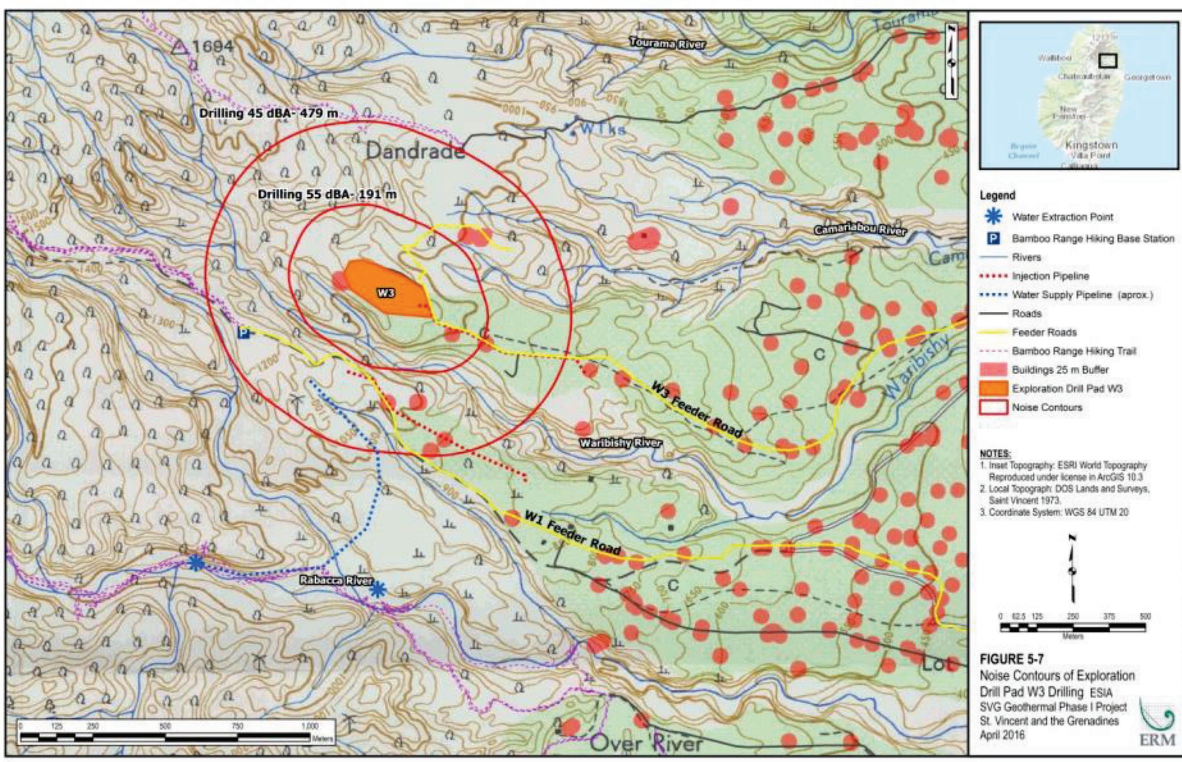


Figure 5-7: Noise Contours of Exploration Drill Pad W3 Drilling

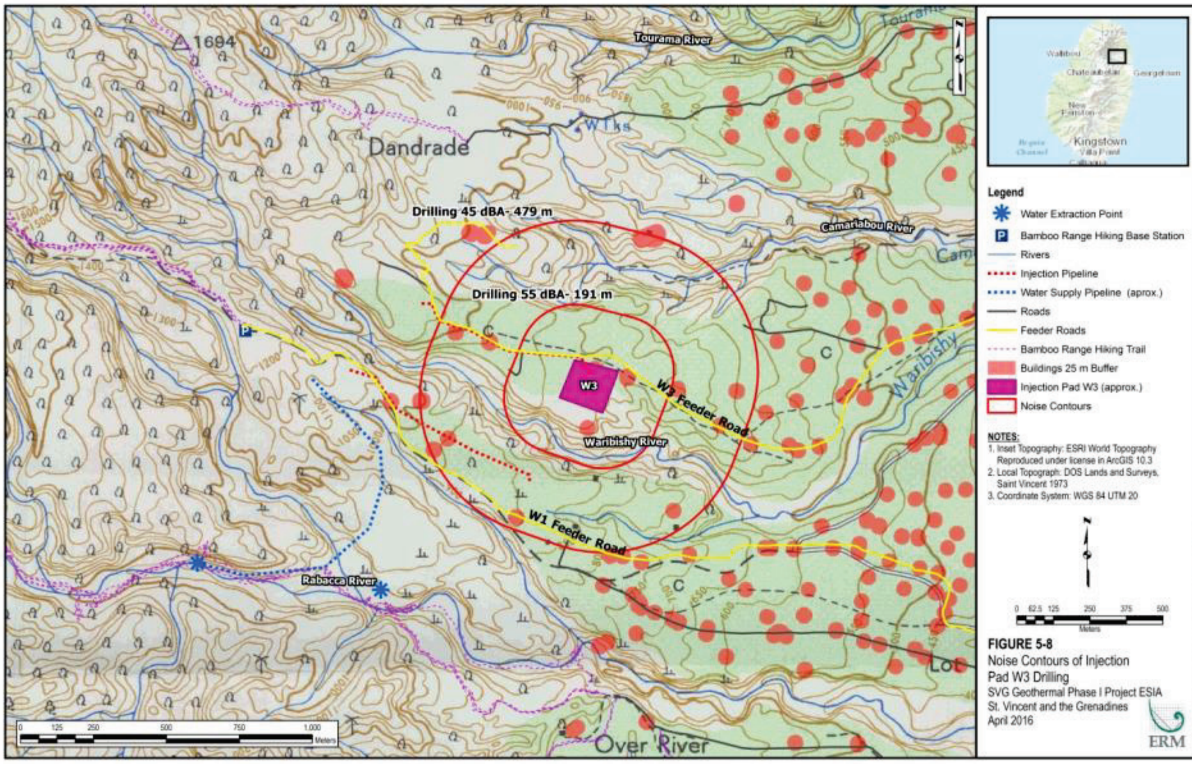


Figure 5-8: Noise Contours of Injection Pad W3 Drilling

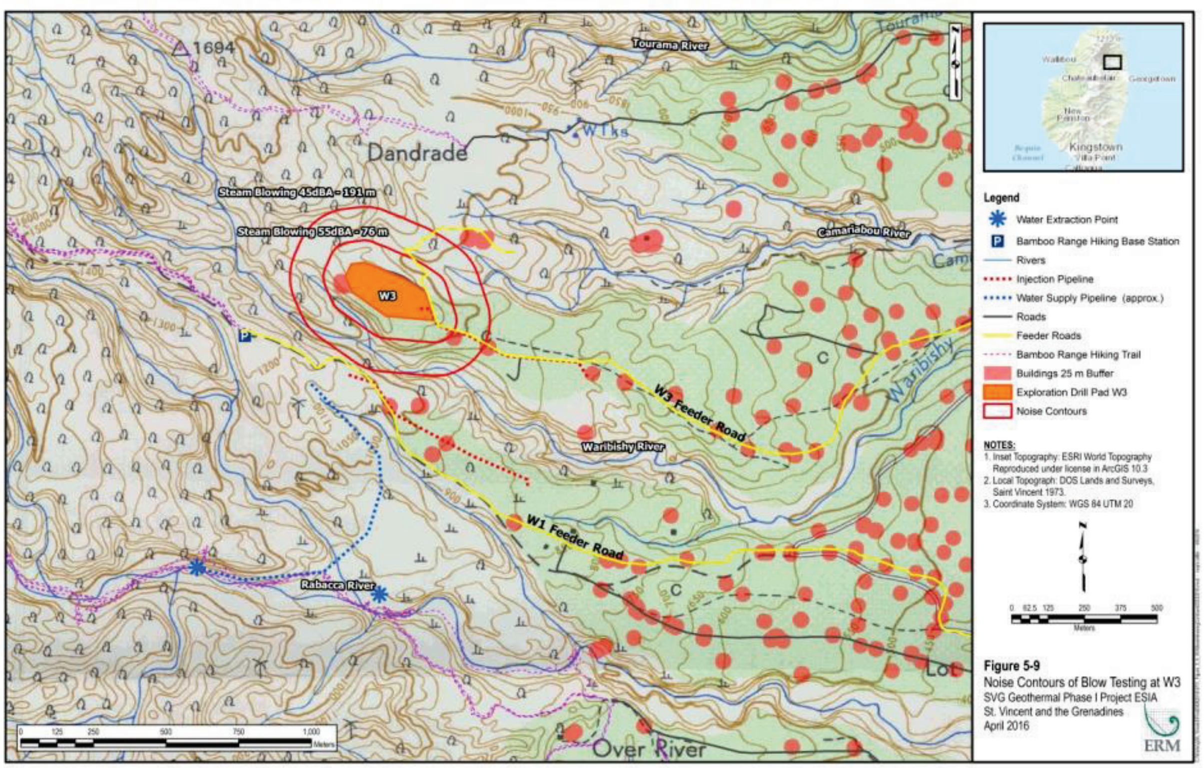


Figure 5-9: Noise Contours of Blow Testing at W3

5.2.2.6 *Noise Impact Significance*

Based on the analysis provided in Table 5-7, the impact significance of increases in airborne noise levels during daytime exploratory drilling would be *Negligible* due to the *Negligible* airborne noise impact magnitude (i.e., less than 65 dBA) at receptor locations N1, N2, and N3. Noise impact at N4 would be *Minor* (*Small* impact magnitude; 65 to 70 dBA) and noise impact at N5 and N6 would be *Major* (*Large* impact magnitude; > 75 dBA). The highest noise increase above ambient levels during the daytime drilling would occur at N5 and N6 (i.e., 50.4 dBA above ambient levels).

Based on the analysis provided in Table 5-8, the impact significance of increases in airborne noise levels during nighttime exploratory drilling would be *Negligible* due to the *Negligible* airborne noise impact magnitude (i.e., less than 65 dBA) at receptor locations N1, N2, N3, and N5. Noise impact at N4 and N6 would be *Minor* (*Small* impact magnitude; 65 to 70 dBA) and *Major* (*Large* impact magnitude; > 75 dBA), respectively. The highest noise increase above ambient levels during the nighttime drilling would occur at N6 (i.e., 63.7 dBA above ambient levels).

The *Major* noise impact designation for N5, a farmer worker camp (daytime only), and N6, residential building (daytime and nighttime), are due to their proximity to the exploratory drilling (i.e., both receptors are currently located within injection pad W1 and W3 boundaries where the drilling would occur). For further discussion on social impacts to these receptors, see Section 5.4, *Socioeconomic and Health Impact Assessment*.

For steam blow testing (after drilling), the impact significance of increases in airborne noise levels during daytime would be *Negligible* due to the *Negligible* airborne noise impact magnitude (i.e., less than 65 dBA) on all receptor locations, except N5 and N6. Noise impact at N5 and N6 would be *Major* (*Large* impact magnitude; greater than 75 dBA) as both receptors are within the exploration drill pad and/or injection pad boundaries. The highest noise increase above ambient levels during the daytime steam blowing would occur at N5 and N6 (i.e., 40.4 dBA above ambient levels). The impact significance of increases in airborne noise levels during nighttime steam blow testing would be *Negligible* due to the *Negligible* airborne noise impact magnitude (i.e., less than 65 dBA) on all receptor locations except N6. The highest noise increase above ambient levels during the nighttime steam blowing would occur at N6 (i.e., 53.7 dBA above ambient levels). Nighttime noise impact at N6 during steam blow testing would be *Major* (*Large* impact magnitude; greater than 75 dBA) because the receptor is located within the injection pad W3 boundary where the steam blow testing would occur.

Noise emissions from drilling vary by drill rigs. Given the modeling results, which predict noise levels in exceedance of international standards extending offsite, and the proximity of agricultural activities and some residences to the Project sites, ERM recommends that noise monitoring be initiated immediately upon commencement of drilling to confirm actual, rather than just predicted, noise levels. If noise levels exceed IFC EHS Guidelines, then SVGCL should develop a Corrective Action Plan to address this non-compliance, which could include additional mitigation or, as a last resort, physical resettlement.

5.2.2.7 *Mitigation Measures*

To avoid or reduce the potential impacts of airborne noise during daytime and nighttime Project activities, the following mitigation measures are recommended (excludes noise controls incorporated into Project design such as installation of silencers on steam vents):

- If possible, relocate noise receptors currently located within W1 and W3 injection pad boundaries or provide temporary housing elsewhere for the entire duration of Project activities.
- Select equipment with lower sound power levels than those assumed for the noise analysis in this assessment.
- Install acoustic barriers/screens or use site objects or topography to block direct line-of-site between high noise-level generating activities and potentially impacted noise receptors. Where acoustic barriers or screens are preferred, they should be constructed without gaps or cracks and with a continuous minimum surface density of 10 kilograms per square meters in order to minimize the transmission of sound through the barrier. Barriers should be located as close as possible to the source or receptor location to be effective.
- Provide ear protection to nearby farmers if noise monitoring indicates noise levels exceed international standards.
- Keep the public informed about the construction, drilling, and testing plans and efforts to minimize noise, and establish procedures for prompt response and corrective action with regard to noise complaints (i.e., grievance mechanism).

5.2.2.8 *Residual Impact (Post-mitigation)*

Implementation of the above mitigation measures during the exploratory activities should reduce the airborne noise levels at the closest receptors to acceptable levels and, as such, would reduce estimated *Major* and *Minor* noise impacts to *Minor* noise impacts. Implementation of a suitable Noise Management Plan (see Chapter 6.0) would assist in maintaining lower noise levels, as well as, determining appropriate actions to mitigate the source of the emission where elevated levels are noted.

5.2.2.9 *Noise Impact Summary*

Table 5-10 provides a summary of potential impacts to noise resources or receptors and describes mitigation measures that would avoid or minimize the potential impacts. Specific impact significance ratings pre-mitigation and post-mitigation (i.e., residual significance) are also provided in the table. Overall, for nearest sensitive receptors, impacts associated with noise range from *Minor* to *Major* under pre-mitigation conditions and *Minor* under post-mitigation conditions.

Table 5-10: Summary of Potential Noise Impacts and Recommended Mitigation Measures

Resource/ Receptor - Impact	Sensitivity	Magnitude	Pre Mitigation Significance	Mitigation Measures	Residual Significance
Human settlements - Potential increase in daytime and nighttime airborne noise levels during Project exploratory drilling	NA	Small to Large	Minor to Major	•If possible, relocate noise receptors located within threshold areas. •Select equipment with lower sound power levels than those assumed. •Install acoustic barriers/screens or use site objects or topography to block direct line-of-site between high noise-level generating activities and potentially impacted noise receptors. •Keep the public informed about the construction, drilling, and testing plans and efforts to minimize noise, and establish procedures for prompt grievance mechanism..	Minor
Human settlements - Potential increase in daytime and nighttime airborne noise levels during Project steam blow testing	NA	Small to Large	Minor to Major	•If possible, relocate noise receptors located within threshold areas. •Select equipment with lower sound power levels than those assumed. •Install acoustic barriers/screens or use site objects or topography to block	Minor

Resource/ Receptor - Impact	Sensitivity	Magnitude	Pre Mitigation Significance	Mitigation Measures	Residual Significance
				direct line-of-site between high noise-level generating activities and potentially impacted noise receptors. • Provide ear protection to nearby farmers if noise monitoring indicates noise levels exceed international standards. •Keep the public informed about the construction, drilling, and testing plans and efforts to minimize noise, and establish procedures for prompt grievance mechanism..	

5.2.3 Soils

5.2.3.1 *Introduction*

This section examines the impacts of the Project on soils. The key impacts considered is the potential increase of soil erosion as the result of soil disturbance and the loss of forests and agro-forest by conversion to non-forest uses. The assessment followed the methodology described in Section 5.1, *General Methodology*.

5.2.3.2 *Identification of Receptors*

As described in Chapter 4.0, *Description of the Existing Environment*, the Project is located in an area on the north region of St. Vincent where agricultural forests are the predominant land use. This area includes agriculture, wooded scrubland, grassy scrubland/pasture, and mature secondary forests. The land use at the proposed exploration drill pads W1 and W3 consist of banana plantations, mango and breadfruit trees, field crops (arrowroot, yams, sweet potato, and other vegetables), and scrub/pasture interspersed with tree crops (citrus, banana, mango and coconut). The most common soils in the Project area are volcanic (Pyroclastic flow and mudflow), which are sandy and highly permeable with good drainage potential and produce dryness in some areas.

The W1 and W3 sites would be located at the base of La Soufrière Volcano hills, where the terrain is steep with slopes greater than 40 degrees. However, the exploration drill and injection pads would be constructed at the less steep areas with maximum slopes of 8 to 18 degrees (see Figure 4-4 in Chapter 4.0, *Description of the Existing Environment*). Nevertheless, these terrain characteristics of the Project area make it prone to landslides and soil erosion.

5.2.3.3 *Relevant Project Activities and Key Potential Impacts*

The construction and operation activities associated with the Project—including land clearance, grading, excavated material disposal, and placement—have the potential to impact the geomorphology, landscape, and soils of the Project area. Potential impacts could include soil erosion and soil contamination. In addition, the construction of exploration drill pads,injection pads, and auxiliary facilities (e.g., water storage pond, feeder road improvements) would result in the loss of land with soils used, or that are suitable for use, for forest and agro-forest activities. A summary of the Project activities and potential impacts, by phase, is provided in Table 5-11.

Table 5-11: Summary of Relevant Project Activities and Potential Key Impacts on Soils

Project Activity	Key Potential Impact
• Land/vegetation clearance and grubbing • Topsoil removal and the nature of the underlying soils and rock that would be exposed • Excavation • Excavated material placement • Feeder road improvements • Landscape grading and re-contouring • Soil stabilization and replacement • Heavy equipment movement during earthwork activities • Wastewater discharges from well pads during drilling and testing phases • Laying pipeline for water supply	• Potential increase in soil erosion (i.e., gully erosion) • Loss of land/soils suitable for agriculture • Potential contamination of soils due to accidental spills/releases • Potential landslides due to steep slopes

Soil erosion/landslides, soil contamination, and loss of land/soils are potential negative impacts on soils of the Project area.

Exploration drill pad W1 would require 70,000 cubic meters (m^3) of total excavated material, of which 30,000 m^3 would be reused for slope stabilization and 40,000 m^3 would be disposed or reused offsite in accordance with environmental acts and regulations of SVG and waste management guidelines established by IFC. Exploration drill pad W3 would produce 55,000 m^3, with 30,000 m^3 reused onsite and 25,000 m^3 disposed or reused offsite. Earthwork activities would also include the excavation of mud ponds and geothermal fluid ponds within the drill pad area, injection pads, and a water storage pond and some rudimentary drainage structures outside. Other activities that may cause soil erosion are associated with runoff from roads (i.e., parallel to the roads or from culverts).

Earthworks and exploration drilling activities would involve the use of equipment/vehicles that use fuels and lubricants, and generate some hazardous materials. Localized soil contamination can occur if this equipment does not receive proper and frequent maintenance or if a suitable area is not assigned for storage of hazardous materials, lubricants, and fuels.

5.2.3.4 *Description of Sensitivity and Magnitude Designation*

The criteria used for the impact assessment of soils are summarized below. Table 5-12 provides the criteria used to assign sensitivity levels for affected resources, while Table 5-13 provides the criteria used to assign magnitude levels for the types of impacts considered in this assessment. Once magnitude and sensitivity levels are assigned for each impact considered, the matrix presented in Table 5-2 is used to assign impact significance ratings.

Table 5-12: Sensitivity Citeria for Soils

Sensitivity	Description
Low	• Soils with low-medium erosion potential • Soils with low potential for compaction
Medium	• Soils with medium and/or high erosion potential that drain to water resources that support diverse aquatic habitats or are a locally important source of potable water for communities living nearby • Soils with medium potential for compaction
High	• Soils with medium and/or high erosion potential that drain to water resources that support economically important or biologically unique aquatic species or provide essential habitat for those species, or are an important source of potable water and/or for navigation • Soils with high potential for compaction

Table 5-13: Magnitude Criteria for Soils

Magnitude	Description
Soil Erosion, Soil Contamination, Soil Compaction	
Negligible	• Disturbance of soils with low erosion potential and in landscapes with slopes < 3 degrees • Disturbance of soils with low compaction potential
Small	• Greater than 0% but less than 25% of soils disturbed have a medium or high erosion potential and are in landscapes with slopes 3 to 17 degrees. • Greater than 0% but less than 25% of soils disturbed have high compaction potential
Medium	• 25% to 50% of soils disturbed have a medium or high erosion potential and are in landscapes with slopes 3 to 17 degrees. • 25% to 50% of soils disturbed have a high compaction potential
Large	• More than 50% of soils disturbed have a medium or high erosion potential and are in landscapes with slopes 3 to 17 degrees. • More than 50% of soils disturbed have a high compaction potential

5.2.3.5 *Description of Impacts, Mitigation Measures, and Residual Impacts*

One of the primary concerns during construction activities is soil erosion/landslides. Potential impacts to soils from erosion are expected to primarily occur in areas where the slopes are moderately steep or steep (i.e., 3 to 17 degrees slopes). Based on the regional geomorphology and topography characteristics, there are areas within the Project footprint that have slopes in the range of 3 to 17 degrees and where the erosion potential of the soils due to their characteristics (sand) is *Medium* or *High* (see Figure 4-4 in Chapter 4.0, *Description of the Existing Environment*). The significance of soil erosion/landslides is characterized *Moderate* based on the *Medium* magnitude of the impact and *Medium* sensitive ratings of the receptor (see Table 5-12 and Table 5-13).

To reduce the significance of construction-related soil erosion/landslides impacts, the following mitigation measures are recommended:

- Develop and implement a Soil Erosion and Sediment Control Plan including control measures such as the use of silt fences, installation of temporary and permanent drainage systems to manage water runoff from the construction areas, and use of sediment basins;
- Use appropriate best management practices during clearance activities, to the extent practicable, such as: schedule construction activities during the dry season, especially on steeply sloped areas; limit clearing and disturbance to the approved work zone area only; minimize the area of bare soil at any one time within the approved work zone as much as possible; and progressively stabilize and revegetate disturbed areas;
- Improve feeder roads with adequate drainage ways; and
- Reuse excavated material for slope stabilization of the exploration drilling and injection pads.

Based on implementation of these measures, the magnitude of impact is expected to be reduced to *Small*, meaning that significance would be reduced to *Minor.*

Project construction would require the use of equipment and vehicles to conduct earthworks, clearing, grubbing, and drilling activities. Accidental spills from this equipment, from vehicles, and from areas assigned to store fuels, lubricants, and hazardous materials could occur, which would result in soil contamination. The significance of soil contamination due to spills is *Minor* considering the *Small* magnitude of the impact due to its local extent, uncertain likelihood, and temporal duration; and *Medium* sensitivity of the receptors (soils).

To reduce the significance of construction-related soil contamination impacts, the following mitigation measures are recommended:

- Implement a Spill Prevention Control and Countermeasures (SPCC) Plan to minimize the risk of spills and ensure an appropriate response in the event of a spill. This Plan should include:
  - Preventive maintenance programs for equipment and vehicles (according to manufacturer requirements); and
  - Properly stored and use of fuel and hazardous materials in assigned areas that control potential accidental spills;
- Inject geothermal fluids into injection wells;
- Provide appropriate facilities/containers for segregation and temporary storage of general wastes onsite; and
- Establish site-specific processes for material, handling (receipt, unloading), storage, transportation, and disposal (including recycling/reuse options).

Based on implementation of these measures, the magnitude of soil contamination impacts due to spills is expected to be reduced to *Negligible*, and the significance would be reduced to *Negligible.*

The potential impact of the Project to soils suitable for agriculture (forest, agriculture, and pastures cultivated and herbaceous agriculture) uses consists of the loss by conversion to non-agriculture uses. The impacts to agriculture soils within the Project area are assessed as *Minor* because the total area of soils suited for agriculture use that would be permanently impacted by conversion to non-agriculture uses is approximately 14 hectares (including feeder roads) of the soils impacted (*Small* magnitude). The impacted areas consist of soils that drain to water resources that support diverse aquatic habitats (*Medium* sensitivity).

Even though the significance of land conversion impacts is considered to be *Minor*, the following mitigation measures are recommended:

- Stabilize disturbed areas with vegetation or other means to minimize soil erosion; and
- Replace topsoil in the excavated material placement areas to approximate the existing geomorphology and landscape/topography and grade and re-contour to ensure proper drainage.

Implementation of these mitigation measures would reduce the magnitude of the impact of the proposed Project on soils to *Negligible*, meaning that significance would be reduced to *Negligible* (see Table 5-14).

5.2.3.6 *Soils Impact Summary*

Table 5-14 provides a summary of potential impacts to soils and describes mitigation measures that would avoid or minimize the potential impacts. Specific impact significance ratings pre-mitigation and post-mitigation (i.e., residual significance) are also provided in the table. Overall, impacts associated with soil range from *Moderate* to *Minor* under pre-mitigation conditions and *Minor* to *Negligible* under post-mitigation conditions.

Table 5-14: Impacts to Soils

Receptor	Sensitivity	Impact	Magnitude	Pre Mitigation Significance	Mitigation Measures	Residual Significance
Soil	Medium	Soil erosion and landslides	Medium	Moderate	Plant vegetation along steep slopes; Prepare and implement a Soil Erosion and Sediment Control Plan; Use appropriate best management practices during clearance activities; Reuse excavated material.	Minor
	Medium	Soil contamination	Small	Minor	Preventive maintenance programs for equipment and vehicles (according to manufacturer requirements); Properly store and use of fuel and hazard materials; Control soil erosion in construction areas (hay bales and silt fences); Inject geothermal fluids.	Negligible
	Medium	Loss of soils suitable for agriculture	Small	Minor	Minimize Project footprint to the maximum extent possible; stabilize disturbed areas.	Negligible

5.2.4 *Water Resources*

5.2.4.1 *Introduction*

This section presents the evaluation of Project impacts on water resources located within the Project area . The significance of the potential impacts on water resources (ground and surface) were evaluated by considering the magnitude of potential changes in hydrologic patterns, water consumption, and changes in surface and groundwater quality.

5.2.4.2 *Identification of Key Receptors*

As described in Chapter 3.0, *Description of the Proposed Project*, the Rabacca River is the main source of water for activities associated with the Project. This river usually experiences low flow during the dry season (December to June), and every year it transports over a million tons of gravel to the coast (Nippon Koei *et al.* 2015). However, the exact amount of total sediments has not been quantified. Due to high flow events and steep river gradient, the Rabacca River frequently transports boulders and cobbles.

The Project Area is located within the North of Georgetown aquifer unit, where the geology is characterized by Pleistocene pyroclastic and lavas of La Soufrière Volcano. The North of Georgetown aquifer unit exhibits high and very high permeability (Murray 2014). Groundwater within the Project area has not yet been studied, and there is limited or no available information regarding groundwater levels or quality; however, because of high rainfall volumes, groundwater is usually not used as a water supply source in the Project area.

5.2.4.3 *Relevant Project Activities and Key Potential Impacts*

The construction and testing activities associated with the Project may result in negative impacts to water resources within the Project footprint (a detailed description of proposed Project features and activities is provided in Chapter 3.0, *Description of the Proposed Project*). Potential impacts could include changes to downstream surface runoff patterns; over-extraction of surface water from the Rabacca River; and changes in surface and groundwater quality. Table 5-15 summarizes the activities and potential impacts associated with the Project.

Table 5-15: Summary of Relevant Project Activities and Potential Key Impacts on Water Resources

Project Activity	Key Potential Impact
• Access improvements and transportation • Drill site preparation (i.e., earthwork, clearing, and grubbing works) • Drill rig installation and drilling • Exploratory blow testing • Injection of geothermal fluids	• Potential over-extraction of watercourses (i.e., Rabacca River) • Changes to downstream surface runoff patterns • Silting of watercourses • Potential degradation of surface and groundwater quality due to accidental spills/releases or geothermal fluids

Drill fluids would be temporarily stored in the mud pond while the injection well is constructed. Drilling and injection works have the potential to affect groundwater quality if geothermal liquid, wash water, mud, and drill cuttings (collectively referred to as "process wastewater") are not managed properly. Also, if equipment and machinery used during construction activities do not receive appropriate and scheduled maintenance, they would have the potential to leak fuel or lubricants that can reach surface water (streams/rivers) or groundwater bodies. Waste fuel, lubricants and/or any hazardous material/waste would be properly managed (collection, store, transportation, and disposal) by SVGCL and their contractors in accordance with the SVG regulations and the IFC Environmental, Health, and Safety (EHS) Guidelines .

Total volume of hazardous materials has not been estimated yet, but it should be relatively small for this type of Project (IFC 2007).

The earthworks, clearing/grubbing, and drilling activities within the Project Area would require the use of heavy equipment (i.e., excavators, drill rig). Operation and maintenance of this equipment would involve the transportation, handling, and storage of fuel and lubricants. Solid and hazardous waste generated would require proper handling and disposal to avoid accidental spills or releases (i.e., fuel, lubricants, waste, etc.) that can adversely impact surface water or groundwater quality.

5.2.4.4 *Description of Sensitivity and Magnitude Designation*

Based on construction and testing activities related to the Project, as well as sensitivity factors defined by social and biodiversity teams (see Section 5.3, *Biodiversity Impact Assessment,* and Section 5.4, *Socioeconomic and Health Impact Assessment*, for more details), ERM identified rivers/streams and groundwater as water resource sensitive receptors. The rivers/streams receptors include Rabacca River, Waribishy River, Camariabou River, and Tourama River. Of these rivers, Rabacca River was identified as the most sensitive surface water receptor as it would be used to supply water for the drilling activities. The other three rivers have the potential for alterations in water quality and changes in runoff patterns associated to earthworks, clearing, and grubbing activities associated with the construction of exploration drill, injection pads, mud ponds, and feeder road improvements. Groundwater was identified as a sensitive receptor as drilling/injection activities have the potential to alter groundwater quality and quantity. Both receptors were identified to present potential water quality/quantity impacts due to their proximity to the Project area. Table 5-16 shows a description of sensitivity designation for water resources used to evaluate the sensitivity of the receptors in the Project Area.

For purposes of this assessment, the sensitivity of the receptors to surface water and groundwater impacts from the Project is classified as *Medium* due to their use to support aquatic habitat (rivers) and a potential future use as a water source for drinking water (groundwater). As mentioned above, Rabacca River is rarely used for fishing and is not used as a drinking water source by the nearby communities.

Table 5-16: Description of Sensitivity Designation for Water Resources

Sensitivity	Description
Rivers/streams	
Low	The rivers/streams have little or no role in terms of provisioning or services for the local community. The rivers do not support diverse aquatic habitat or populations. Rivers support aquatic habitat or population that is of low quality.
Medium	The rivers have local importance in terms of provisioning services, but there is ample capacity and/or adequate opportunity for alternative sources of

Sensitivity	Description
	comparable quality. The rivers support diverse populations of flora and/or fauna.
High	The rivers/streams are wholly relied upon locally, with no suitable technically or economically feasible alternatives, or are important at a regional or transboundary watershed level for provisioning services or contribution to groundwater dependent ecosystems (i.e., transboundary rivers). The rivers support economically important or biologically unique aquatic species that provides essential habitat for such species.
Groundwater	
Low	Groundwater has little or no role in terms of provisioning or services for the local community.
Medium	Groundwater has local importance in terms of provisioning services, but there is ample capacity and/or adequate opportunity for alternative sources of comparable quality.
High	Groundwater is wholly relied upon locally, with no suitable technically or economically feasible alternatives, or is important at a regional or transboundary watershed level for provisioning services.

The types of Project-related impacts on water resources considered in this assessment were included in Table 5-15. Table 5-17 presents a description of magnitude criteria for impacts on surface water and groundwater sources in general. For surface water quality, United States guidelines are used as reference given SVG does not have national water quality standards. Based on the potential impacts on water resources and description of Project activities, the magnitude of impacts on surface water and groundwater quality is *Medium* without the implementation of any mitigation measures. For surface hydrology, the magnitude of impacts is *Large* without the implementation of any mitigation measures due to water extraction activities in Rabacca River to supply water for the Project (see Table 5-18). Impacts on groundwater levels are *Small* because groundwater levels are likely to be within ambient ranges. Groundwater is not a water source used by local communities within the Project area.

Table 5-17: Description of Magnitude Criteria for Water Resources

Magnitude	Description
Surface water quality	
Negligible	Less than 10% increase over baseline in any parameter and meeting SQuiRT guidelines for freshwater
Small	10 to 50% increase over baseline in any parameter and meeting SQuiRT guidelines for freshwater
Medium	50 to 100% increase over baseline in any parameter and meeting SQuiRT guidelines for freshwater
Large	>100% increase over baseline in any parameter or exceeding SQuiRT guidelines for freshwater.
Hydrology (flow changes)	
Negligible	<5% change in minimum flow
Small	5 to 10% change in minimum flow
Medium	10 to 20% change in minimum flow
Large	>20% change in minimum flow

Magnitude	Description
Groundwater quality and quantity	
Negligible	*Groundwater Quality Related* • Groundwater quality impacts are likely to be well within ambient ranges or allowable criteria. • Short-term localized effects on groundwater quality but likely to be highly transitory (i.e., lasting a matter of hours) and well within natural fluctuations. • There are no known/expected downgradient groundwater users within the watershed that could be affected by the Project. *Groundwater Quantity Related* • Impacts to groundwater levels are likely to be well within ambient ranges. • Short-term localized effects on groundwater levels, but likely to be highly transitory (i.e., lasting a matter of hours) and well within natural fluctuations • There are no known/expected groundwater users within the watershed that could be affected by the Project.
Small	*Groundwater Quality Related* • Groundwater quality impacts are likely to be within ambient ranges or allowable criteria and have no effects offsite. • Short-term localized effects on groundwater quality, but which are likely to return to equilibrium conditions within a short timeframe (i.e., hours or days at most) • There are known/expected downgradient groundwater users within the watershed, but their supplies may not be compromised by the Project. *Groundwater Quantity Related* • Impacts to groundwater levels are likely to be within ambient ranges. • Short-term localized effects on groundwater levels, but likely to return to equilibrium conditions within a short timeframe (i.e., hours or days at most) • There are known/expected groundwater users within the watershed, but their supplies may not be compromised by the Project.
Medium	*Groundwater Quality Related* • Groundwater quality impacts are likely to result in occasional exceedances of ambient ranges or allowable criteria and extend off-site. • Localized effects on groundwater quality that are likely to be fairly long-lasting (i.e., weeks or months) and/or give rise to indirect ecological and/or socioeconomic impacts • There are known/expected downgradient groundwater users within the watershed, and their supplies may be compromised by the Project under certain (i.e., drought or seasonal low flow) conditions. *Groundwater Quantity Related* • Impacts to groundwater levels are likely to result in occasional exceedances of ambient ranges. • Localized effects on groundwater levels are likely to be fairly long-lasting (i.e., weeks or months) and/or give rise to indirect ecological and/or socio-economic impacts. • There are known/expected groundwater users within the watershed, and their supplies may be compromised by the Project under certain conditions (i.e., drought or seasonal low flow).

Magnitude	Description
Large	*Groundwater Quality Related* • Groundwater quality impacts are likely to routinely or permanently exceed ambient ranges or allowable criteria over large areas and affect off-site users. • Severe effects on groundwater quality that are likely to be long-lasting (i.e., months or more), permanent, and/or give rise to indirect ecological and/or socioeconomic impacts • There are known/expected downgradient water users within the watershed, and their supplies are likely to be compromised by the Project at most times. *Groundwater Quantity Related* • Impacts to groundwater levels are likely to routinely or permanently exceed ambient ranges. • Severe effects on groundwater levels are likely to be long-lasting (i.e., months or more), permanent, and/or give rise to indirect ecological and/or socioeconomic impacts. • There are known/expected groundwater users within the watershed, and their supplies are likely to be compromised by the Project at most times.

SQuiRT: Screening Quick Reference Tables (US NOAA 2016), given there are no national standards.

5.2.4.5 Description of Impacts, Mitigation Measures, and Residual Impacts

To evaluate potential impacts on the Rabacca River due to water extraction required for the Project, ERM used the available historical streamflow data for the January 2009 to June 2010 period (see Table 4-18) and water consumption and recirculation scenarios shown in Figure 3-11 (see Chapter 3.0, *Description of the Proposed Development*). According to this information, exploratory drilling activities include four stages with up to 3456 m^3 per day (m^3/d) (40 liters per second [L/s]) of water use:

- _Stage 1 (surface casing)_ would last for approximately 7 days and requires an estimated 1,555 m^3/d (18 L/s) of water. Only 17.3 m^3/d (0.2 L/s) of water would be extracted from Rabacca River for 7 days during Stage 1 as 99 percent of the 1,555 m^3/d used in this stage would be recirculated from the drill process to the mud tank. The remaining 1 percent of water would be accumulated in the mud pit.
- _Stage 2 (anchor casing)_ would last for approximately 18 days and requires an estimated 3,456 m^3/d (40 L/s) of water. However, only 17.3 m^3/d (0.2 L/s) of water would be extracted from Rabacca River for 18 days during Stage 2 as 99.5 percent of the 3,456 m^3/d used in this stage would be recirculated from the drill process to the mud tank. The remaining 0.5 percent of water would be accumulated in the mud pit.
- _Stage 3 (production casing)_ would last for approximately 22 days and requires an estimated 3,456 m^3/d (40 L/s) of water. However, only 17.3 m^3/d (0.2 L/s) of water would be extracted from Rabacca River for 18 days during Stage 2 as 99.5 percent of the water used in this stage would be recirculated from the drill process to the mud tank. The remaining 0.5 percent would be accumulated in the mud pit.

- *Stage 4 (perforated liner)* would last for approximately 20 days and may require up to 3,456 m^3/d (40 L/s) of water. At this stage, water would not be recirculated as it would be lost to the well and total volume of 69,120 m^3 would be extracted from Rabacca River over a 20-day period.

Table 5-18 presents results of a water availability analysis conducted to determine if Rabacca River has the capacity to supply water for the Project without using all the water available in the river and/or affecting aquatic biodiversity, especially during the dry season. For this analysis, ERM used available minimum monthly flows (2009 to 2010) and precipitation data from the Rabacca water level and rain station, respectively, provided by the Central Water and Sewerage Authority (CWSA). A maximum water extraction rate of 0.04 m^3/s (3,456 m^3/d), equivalent to Stage 4 described above, was used to estimate if Rabacca River can meet the Project's estimated water demand. It was assumed that only 50 percent of the minimum streamflow can be extracted from the river without causing significant impact. The results indicate that, on average, water can be extracted from the Rabacca River from July to November, and possibly in May (see Table 5-18) without producing significant/negative impacts on social and/or biodiversity receptors. However, if water is extracted during the dry months (December to April), the magnitude of the impact would be deemed as *Large* because the maximum flow required for the Project is approximately four times greater than the minimum flow recorded at Rabacca River. This situation also affects Stage 4 drilling given the lack of reliability on water supply.

Table 5-18: Water Availability Analysis for the Project at Rabacca River

Month	Min. Q(m^3/s) 2009-2010 [a]	Avg. Precipitation 2009-2016[b]	Avg. Precipitation 2009-2010 [b]	50% of Q (m^3/s) min	Max Q(m^3/s) required by the Project (Drilling)[b]	Water extraction without taking all water from Rabacca River
January	0.015	138	129	0.008	0.04	No
February	0.011	111	17	0.006	0.04	No
March	0.011	127	39	0.006	0.04	No
April	0.012	240	108	0.006	0.04	No
May	0.083	181	208	0.042	0.04	Yes
June	0.014	149	184	0.007	0.04	No
July	---	206	265	---	0.04	Yes*
August	---	236	212	---	0.04	Yes*
September	0.28	256	288	0.140	0.04	Yes
October	0.109	292	318	0.055	0.04	Yes
November	0.103	296	232	0.052	0.04	Yes
December	---	205	182		0.04	No

Q = streamflow; m^3/s= cubic meters per second; Avg = average; Min= minimum; Max = Maximum; Yes*= Estimated based on precipitation trends because no streamflow data was available

[a] Data from Table 4-6: Maximum and Minimum Monthly Water Flow at Rabacca River (Source: CWSA 2015)

[b] Data from Personal communication with CWSA 2016.

[c] Maximum flow require for the Project.

The impact of water extraction on the Rabacca River is given a significance rating of *Major* based on the *Large* magnitude of the impact (regional extent, certain likelihood and temporal duration) and *Medium* sensitivity of the receptor. However, the significance of this impact may be reduce to *Minor* if water extraction is conducted during the wet season and other water sources are used to supply water for the Project during the dry season (i.e., trucking water). Water would be recycled and reused to the maximum extent possible.

Project construction would require the use of equipment and vehicles to conduct earthworks, clearing, grubbing, and drilling activities. Accidental leaks from this equipment, vehicles, and areas assigned to store fuels, lubricants, and hazards material can occur and alter surface quality. Water quality could be altered by increasing turbidity and suspended solids in rivers due to excavation activities; or by hydrocarbons from accidental spills if they are not properly managed. The significance of impacts on surface quality is *Moderate* based on the *Medium* magnitude of the impact due to its local extent, uncertain likelihood, and temporal duration; and *Medium* sensitivity of the receptors (rivers). The significance of impacts on surface and groundwater quality could be reduced to *Minor* to *Negligible* if appropriate mitigation measures are implemented (see Table 5-19).

Geothermal fluids (brine) would be injected underground, well below surface aquifers (~1,000 m). SVGCL proposes the use of lined ponds to temporarily confine the wastewater if the injection wells have not been completed so that they do not cause soil erosion or discharge to watercourses. Also, SVGCL would 1) contain the majority of fluids generated during drilling activities by lining and grouting the drilling wells, and 2) use water-based drilling fluids to reduce impacts on surface and groundwater quality (see Table 5-19). The significance of impacts on groundwater water quality would be *Minor*, without any mitigation measure, based on a *Small* magnitude of the impact and a *Medium* sensitivity of the receptor. However, SVGCL would inject drilling fluids (brine) underground through injection wells at a depth of approximately 1,000 m from 500 m, at a location downhill of the drilling pad. This injection of drilling fluids would help avoid interaction with groundwater and reduce the significance of the impact to *Negligible* (see Table 5-19).

5.2.4.6 *Water Resource Impact Summary*

Table 5-19 provides a summary of potential impacts to water sources and describes mitigation measures that would avoid or minimize the potential impacts. Specific impact significance ratings pre-mitigation and post-mitigation (i.e., residual significance) are also provided in the table. Overall, impacts associated with water sources range from *Major* to *Minor* under pre-mitigation conditions and *Moderate* to *Negligible* under post-mitigation conditions.

Table 5-19: Impacts to Water Resources

Receptor	Sensitivity	Impact	Magnitude	Pre Mitigation Significance	Mitigation Measures	Residual Significance
Rabacca River	Medium	Water flow	Large	Major	Restrict water extraction to wet season when there is ample availability; Trucking water in or store water in tanks and ponds during dry season; monitor streamflow by installing a continuous stream guage.	Moderate-Minor
	Medium	Water quality	Medium	Moderate	Preventive maintenance programs for equipment and vehicles (according to manufacturer requirements); Properly store and use of fuel and hazard materials; Prohibit discharge of untreated wastewater into rivers/streams; Reuse of drilling fluid (where feasible); Control soil erosion in construction areas (hay bales and silt fences); Surface water quality monitoring	Minor to Negligible
Groundwater	Medium	Water quality	Small	Minor	Lining, casing, and grouting the drilling wells; Use water-based drilling fluids; groundwater quality monitoring; Lining drilling water ponds	Negligible

Recommended mitigation measures include:

- Rabacca River Flow
  - Schedule exploratory drilling, especially Stage 4, so that it occurs during the rainy season, or provide alternative sources of water so as to avoid significant reduction in Rabacca River flow;
  - Install a continuous water level recorder on the Rabacca River at the existing stream gauge near SVGCL's proposed water intake to develop a flow record that would allow for better management of the water resource; and
  - Reuse treated stormwater onsite where possible to meet some of the water needs of the Project.

- Surface Water and Groundwater Quality

- Implement preventive maintenance programs for equipment and vehicles (according to manufacturer requirements);
- Implement the recommended soil erosion control mitigation measures (see Section 5.2.3) to avoid the introduction of sediment into surface waters;
- Adopt and implement an SPCC Plan to minimize the potential for accidental spills;
- Provide portable restroom facilities for construction workers;
- Inject geothermal fluids (brine) in injection wells, well below surface aquifer units;
- Provide sufficient process wastewater storage to avoid the release of any untreated water into surface waters;
- Initiate monthly water quality sampling at least at one location upstream of water intake and one location downstream of Project influence for the normal suite of parameters, including the anticipated chemical constituents of the geothermal liquids.

All the construction activities and proposed mitigation measures described above should include surface and groundwater monitoring (see Chapter 6.0, *Environmental and Social Management Plan*).

5.2.5 *Natural Hazards Risk Assessment*

Due to its geographic location, SVG is highly exposed to meteorological and geophysical threats such as earthquakes, landslides, flash flooding, hurricanes, and volcanic eruptions (see Section 4.1.7, *Natural Hazards*).

The Project itself is vulnerable to these natural disasters, which could affect the project during construction, drilling, and testing. Natural hazards also pose a risk to Project workers. For example:

- Hurricanes: SVG is in located within the Eastern Caribbean track (Caribbean Hurricane Network 2011). In the past, hurricanes have caused significant damage to St. Vincent and its infrastructure. A high category hurricane can damage project facilities due to wind and rain, promote landslides, and worsen impacts to the environment.
- Landslides: This has been identified as a concern in the coastal area between Orange Hill and Georgetown and the area around La Soufrière Volcano. Due to the uncompact nature of volcanic material, moderately steep to steep slopes, and high rainfall with frequent intense precipitation storms, the Project Area is considered high risk for landslides (Murray 2014). This could result in damaging project facilities (e.g., damage to pipes and construction equipment); worsen impacts to the environment (e.g., increased risk of erosion, sedimentation, and landslides because of construction activities); and increase the risk to public safety.
- Volcanic eruptions: La Soufrière Volcano is an active volcano, with the most recent eruption in 1979. Volcanic eruption would result in ash/tephra fall; lahar flow (i.e, volcanic mudflow); and volcanic gases emission (CO2, H2S, SO2). These effects could damage Project facilities and associated infrastructure, limit or block access to the site, and threaten worker safety.
- Seismic events: The Eastern Caribbean is a seismically active area. The most recent significant earthquake, 6.5 on the Richter scale, occurred in 2015. A large seismic event could cause landslides and tsunamis, resulting in damage to project facilities, and worsen impacts to the environment.

Careful attention in the design of Project components (i.e., pads, water ponds, feeder roads) must be taken to ensure the Project is resilient to these natural disasters. ERM recommends applying the following design considerations:

- Design and located Project facilities outside of areas subject to flooding – under the current design only water dependent facilities (e.g., Rabacca River water intake) are located in areas subject to flooding;

- Locate component outside identified lahar flow paths – under the current design, both Sites W1 andW3 are located outside of identified lahar flow paths; and
- Determine and install slope protection if possible in most vulnerable areas.

As part of, and in addition to, risk prevention measures, there should be plans in place to assure emergency preparedness and response. During Project activities, SVGCL and the Drilling Contractor should implement and follow an Emergency Response Plan that describes procedures to be implemented both in the event of a forecasted event (e.g., hurricane or tropical storm) or an unanticipated event (e.g., earthquake). This would involve securing equipment and materials, stabilizing disturbed areas, and similar actions as well as procedures for site evacuation.

During scoping meetings and the draft *Stakeholder Engagement Plan* development, community members raised their concern regarding the potential of induced seismicity by the Project. Geothermal production can be related to induced micro-seismicity (Cladouhos *et al.* 2010; U.S. Department of Energy 2012; Bayer *et al.* 2013). It is expected that the Phase I Project would not result in these types of hazards due to the magnitude and duration of the geothermal reservoir extraction and injection during the blow testing period. However, these hazards are described below so that they can be adequately considered for Phase II.

The Eastern Caribbean is a seismically active area with hundreds of earthquakes per year; however, St. Vincent has not been an epicenter of any recent significant earthquakes (see Section 4.1.7, *Natural Hazards*). Geothermal production results from the extraction or circulation of geothermal fluids and/or steam from a geothermal reservoir. Induced micro-seismicity occurs when fluid pressure in a fault or fracture reaches a critical value above which the friction preventing fault slip is overcome (Cladouhos *et al.* 2010). It has been reported in some cases where engineered geothermal development is carried out in seismic active zones; however, it is very site-specific, related to the geological conditions of each project area (Bayer *et al.* 2013). In most cases, micro-seismic events have been of relatively small magnitude (i.e., magnitudes of less than 2.0), and by the time the energy reaches the surface, the vast majority are rarely felt. According the U.S. Department of Energy's *Protocol for Addressing Induced Seismicity Associated with Enhanced Geothermal Systems* (2012):

> although to date there is no recorded instance of a significant danger or damage (significant is defined here as damage that would affect a structure's physical integrity; this is not to say that seismicity has not caused less severe damage such as cracks in walls or similar damage) associated with induced seismicity related to geothermal energy production, the introduction of enhanced geothermal system technology

> in populated areas could be regarded by some as …a potential annoyance factor.

A common practice to identify and monitor the risk of induced micro-seismicity is to establish a local seismic monitoring program. ERM recommends installing a Project seismic monitoring program or connecting with the existing SVG regional seismic monitoring network to obtain accurate baseline of seismic activity before the start of Phase II. During production, it would allow monitoring any changes related to the project and, if necessary, work as an early warning system and provide information to adjust the production plan (e.g., temporarily stop extraction of geothermal fluids). Due to the relative small magnitude of induced micro-seismicity, it is recommended that instrumentation be able to detect events at least as small as magnitude 1.0,(U.S. Department of Energy 2012). The monitoring program would also provide project-specific data in the event the Project-Affected Communities or other Project stakeholders are concerned regarding induced seismicity.

5.3 BIODIVERSITY IMPACT ASSESSMENT

This section describes the Project impacts on terrestrial and freshwater aquatic biodiversity. The receptors selected to assess these potential impacts include terrestrial vegetation, habitat, and wildlife; aquatic habitat and biota; rare and endemic species; and protected areas. These receptors encompass the key terrestrial and aquatic biodiversity components in the Project Area of Influence (AoI).

5.3.1 Biodiversity Impact Assessment Methodology

The impact assessment methodology used for this ESIA combines a receptors' importance and the magnitude of potential impacts to determine the significance of the impact (see Section 5.1, *General Methodology*). Table 5-20 provides a summary of the criteria used to assess the importance of biodiversity receptors for this analysis. Table 5-21 provides the criteria used to assess the magnitude of potential impacts to biodiversity receptors.

Table 5-20: Criteria for Determining Biodiversity Receptor Importance

Importance	Characteristics
Low	Habitats and species with no protected designation or recognition under local, national, or international laws or treaties; habitats and species that are common and widespread within the region or with low conservation interest based on expert opinion; and species listed as Least Concern (LC) on IUCN Red List of Threatened Species
Medium	Habitats and species that are protected under local, national, or international laws or treaties or otherwise recognized by experts as having conservation interest; species listed on the IUCN Red List of Threatened Species as Vulnerable (VU), Near Threatened (NT), or Data Deficient (DD); nationally restricted range species; nationally important concentrations of migratory or congregatory species; and the habitats of significant importance to these species

High	Habitats and species that are protected under local, national, or international laws or treaties or otherwise recognized by experts as having high conservation importance; species listed on IUCN Red List of Threatened Species as Critically Endangered (CR) or Endangered (EN); locally endemic species; regionally or globally important concentrations of migratory or congregatory species; the habitats of significant importance to these species; and habitat or species meets IFC PS 6 criteria for critical habitat

ICUN = International Union for the Conservation of Nature

Based on the above criteria, the biodiversity receptors used in this assessment have the following importance ratings:

- Terrestrial Vegetation and Habitat – *Low* importance because of the disturbed nature of the majority of the vegetation and habitats in the Project Area, the dominance of common and widespread vegetation species, and the habitat's high regenerative capacity. The Project Area does not contain any protected areas, although several abut or occur near the area.
- Terrestrial Wildlife – *Medium* importance because of the relatively high diversity of species that occur in and around the Project Area, including species listed as Vulnerable and Data Deficient by the International Union for the Conservation of Nature (IUCN), and the use of the area as a wildlife movement corridor across La Soufrière Volcano.
- Aquatic Habitat – *Low* importance because the river has been impacted by large-scale, recurring sedimentation events, which limit the availability of high quality benthic habitat in the channel, and therefore limit the sensitivity of the physical habitat in the river to Project-related impacts. The river is not protected or recognized by experts as a habitat of specific conservation interest and supports species listed as Least Concern by the IUCN.
- Aquatic Biota – *Medium* importance because of the presence of migratory invertebrates and fish (all of which are either not assessed or considered Data Deficient by IUCN) and locally important (customarily fished) species. Although the freshwater amphidromous shrimp are listed as Least Concern by the IUCN, they are recognized by experts as a group of conservation interest due to threats to their habitats across the neotropics and the Caribbean.
- Rare and Endemic Species – *Medium/High* importance because of the mix of IUCN Red List Vulnerable and Endangered species and regional and local-endemic species that occur within and around the Project Area.
- Protected Areas – *High* importance due to their nationally protected status and their importance to the maintenance of rare and endemic species populations.

Table 5-21: Criteria for Assessing Impact Magnitude on Biodiversity Resources (Habitats and Species)

Magnitude	Characteristics
Negligible	Effect is within the normal range of natural variation for the affected habitat or the populations of affected species.
Small	Affects only a small area of habitat, such that there is no loss of viability or function of the habitat. Effect does not cause a substantial change in the populations of affected species or other species dependent on them.
Medium	Affects a portion of a particular habitat, but does not threaten the long-term viability or function of the habitat. Effect causes a substantial change in abundance and/or reduction in distribution of a population over one or more generations, but does not threaten the long-term viability of that population or any population dependent on it.
Large	Affects the entire habitat, or a significant proportion of it, and the long-term viability/function of the habitat is threatened. Affects the entire population of a particular species or subspecies, or a significant part of it, causing a substantial decline in abundance, and/or change in and recovery of the population (or another dependent on it) is not possible either at all or within several generations due to natural recruitment (reproduction, immigration from unaffected areas).

Impacts to biological resources can be divided into two broad categories: direct and indirect. Direct impacts consist of physical disturbance or damage to a habitat or species. Examples include, but are not limited to:

- Disturbance or loss of habitat;
- Mortality or injury to individuals (particularly species of conservation concern); and
- Habitat fragmentation.

Indirect impacts occur when Project-related activities affect biological resources in a manner other than a direct loss of the resource. Examples include, but are not limited to:

- Disturbance of wildlife, leading to displacement of wildlife from suitable habitats;
- Changes in an individual's or population's habitat use or life history pattern due to disturbance from increased noise, vibration, lighting, human activity, visual disturbance, or transportation activity;
- Increased competition for resources or habitat due to displacement of individuals from the affected area into the territory of other animals;
- Degradation of water quality leading to impacts on aquatic biota; and
- Increased hunting/fishing pressure due to human population influx.

Direct and indirect impacts to biodiversity can occur during the following Project activities:

- Access improvements and transportation, which may result in vegetation loss, noise, and vehicular mortality;
- Drill site preparation, which would result in vegetation loss, noise, and wildlife disturbance and displacement;

- Drill rig installation and drilling, which would create noise and air emissions and related disturbance of wildlife and require water abstraction; and
- Exploratory testing, which would create noise and air emissions.

The decommissioning phase would create additional human activity and disturbance at the sites, but these effects would be *Negligible* since wildlife use of the sites and immediate vicinity would be very limited following drilling and testing due to the noise from the activities. This phase would ultimately result in cessation of Project activities and restoration of pre-Project conditions.

5.3.2 Biodiversity Impact Discussion

Based on the proposed Project activities outlined in Chapter 3.0, *Description of the Proposed Project*, Table 5-22 provides a summary of the potential sources of direct and indirect Project impacts on terrestrial and aquatic biological resources.

Table 5-22: Summary of Potential Project Impacts on Terrestrial and Aquatic Biological Resources

Impact Type	Project Activities
Direct	*Terrestrial Impacts* • Ground works would result in the direct loss and disturbance of vegetation and wildlife habitat and may introduce or spread invasive and exotic plant species within the road improvement/expansion locations, exploration well pads, and injection pads and immediate surrounding areas. • The use of heavy machinery during construction and increased vehicular traffic along access roads could result in direct mortality or injury of wildlife species. • The use of heavy machinery during construction and well drilling may generate localized vibrations sufficient to harm ground-dwelling terrestrial biota. • Project-related vehicular traffic may cause vehicular-related wildlife mortality or injury. *Freshwater Aquatic Impacts* • Clearing vegetation to improve feeder roads and prepare exploration drill pads and injection pads has the potential to destabilize soils and increase sedimentation in the Rabacca River, particularly in the riparian corridor south of the W1 site and feeder road. • Installation of the water intake structure has the potential to injure or kill aquatic fauna. • Entrainment in the water intake has the potential to kill larval aquatic organisms. • Water withdrawals from the Rabacca River have the potential to decrease available aquatic habitat and fragment existing aquatic habitat in the Rabacca River.
Indirect	*Terrestrial Impacts* • Project-related vehicular traffic and site preparation activities may create dust, the accumulation of which can inhibit vegetative growth. • Operation of the drill rig and steam blow testing would create noise, causing wildlife displacement from the drill sites and the surrounding vicinity, which would modify wildlife use of the affected area and temporarily fragment habitat. • Operation of the drill rig and related drilling and testing activities would generate air emissions, the accumulation of which could inhibit growth of vegetation or adversely affect susceptible wildlife resources. • Project-related activities would indirectly result in the temporary degradation of habitat quality within the protected areas located immediately adjacent to the pad sites including La Soufrière National Park and Mount Pleasant Forest Reserve. *Freshwater Aquatic Impacts* • Unplanned events such as spills or leaks of hazardous materials or brine could degrade water quality and cause stress or mortality of aquatic organisms. • Project-related influx of workers and improved road access to La Soufrière Volcano could increase hunting or fishing pressure and mortality of terrestrial and aquatic biota.

Table 5-23 summarizes the receptor sensitivity, potential Project impacts, impact magnitude, and overall unmitigated and residual Project impacts to biodiversity receptors.

Table 5-23: Summary of Impacts to Biodiversity Receptors

Receptor	Sensitivity	Impact	Magnitude	Pre-mitigation Impact Significance	Mitigation Measures	Residual Impact Significance
Terrestrial Vegetation	Low	**Direct**: Ground works would result in the direct loss and disturbance of vegetation and wildlife habitat within the road improvement/ expansion locations, exploration well pads, and injection pads and immediate surrounding areas.	Small	**Negligible**	Minimize Project footprint to the maximum extent possible.	**Negligible**
		Direct: Ground works and Project-related vehicle traffic and equipment brought from foreign countries may introduce or spread invasive and exotic plant species.	Small	**Negligible**	None.	**Negligible**
		Indirect: Project-related vehicular traffic and site preparation activities may create dust, the accumulation of which can inhibit vegetative growth.	Small	**Negligible**	Implement dust control procedures (e.g., watering) when needed to control dust.	**Negligible**
Terrestrial Wildlife	Medium	**Direct**: The use of heavy machinery during construction and increased vehicular traffic along access roads could result in direct mortality or injury of wildlife species.	Small	**Minor**	Conduct pre-clearing surveys prior to site preparation activities to flush wildlife from the activity areas and relocate sessile species to undisturbed sites to the extent practicable. Implement a Journey Management Plan including strict enforcement of speed limits and limit nighttime driving.	**Negligible**
		Direct: The use of heavy machinery during construction and well drilling may generate localized vibrations sufficient to harm ground-dwelling terrestrial biota.	Small	**Minor**	Implement to pre-clearing surveys described above to relocate ground dwelling wildlife from the activity sites to the extent practicable.	**Negligible**

Receptor	Sensitivity	Impact	Magnitude	Pre-mitigation Impact Significance	Mitigation Measures	Residual Impact Significance
		Indirect: Operation of the drill rig and blow testing would create noise (see Section 5.2.2) and introduce artificial light, causing wildlife displacement from the drill sites and the surrounding vicinity, which would modify wildlife use of the affected area and temporarily fragment habitat.	Medium	**Moderate**	Implement the noise reduction measures defined in Section 5.2.2. Minimize the amount of artificial lighting used at the pad sites and use directional lighting (downward facing lighting).	**Minor**
		Indirect: Project-related influx of workers and improved road access to La Soufrière could increase hunting or fishing pressure and mortality of terrestrial and aquatic biota.	Small	**Minor**	Implement and enforce strict no hunting and freshwater fishing policy for Project workers	**Negligible**
Aquatic Habitat	Low	**Direct:** Clearing vegetation to improve feeder roads and prepare well pads would destabilize riparian areas and increase sedimentation in the Rabacca River, particularly in the riparian corridor south of the W1 exploratory well pad, feeder road, and injection pad.	Small	**Negligible**	Implement erosion control measures in all project activity areas defined in Section 5.2.3.	**Negligible**
		Direct: Water withdrawals from the Rabacca River may decrease available aquatic habitat and fragment existing habitat in the Rabacca River.	Medium	**Minor**	Minimize water intakes during low flow periods.	**Negligible**
		Indirect: Unplanned events such as spills or leaks of hazardous materials or brine could degrade water quality and cause stress or mortality of aquatic organisms in the Rabacca River.	Small	**Negligible**	Implement a spill prevention control and countermeasures plan.	**Negligible**
Aquatic Biota	Medium	**Direct:** Installation of the water intake structure may injure or kill aquatic fauna within the footprint of the intake structure.	Negligible	**Negligible**	None.	**Negligible**
		Direct: Entrainment in the water intake has the potential to kill larval aquatic organisms.	Medium	**Moderate**	Install wedgewire screens on the water intake. Reduce velocity of the water intake during abstraction.	**Minor**

Receptor	Sensitivity	Impact	Magnitude	Pre-mitigation Impact Significance	Mitigation Measures	Residual Impact Significance
		Indirect: Water abstraction may result in loss of aquatic habitat continuity and may interrupt migrations required to complete life cycles.	Medium	**Moderate**	Minimize water intakes during low flow periods.	**Minor**
		Indirect: Influx of workers may increase fishing pressure leading to increased mortality of aquatic organisms.	Small	**Minor**	Implement and enforce a strict no hunting policy for Project workers.	**Negligible**
Rare and Endemic Species	Medium-High	**Direct**: Ground works may result in the direct loss and disturbance of rare and endemic plants and animals (particularly sessile animals that cannot move away from Project activities and disturbance) within the exploration well pads and injection pads.	Medium	**Moderate-Major**	Conduct pre-clearing survey and relocate any rare or endemic species found onsite prior to drilling activities.	**Minor**
		Indirect: Project-related vehicular traffic and site preparation activities may create dust, the accumulation of which can affect growth of rare and endemic plants.	Small	**Minor-Moderate**	Conduct a St. Vincent Parrot population census in the forests surrounding the pad sites to establish a baseline to monitor the impacts of the Project on this species. Implement dust control procedures (e.g., watering) when needed to control dust.	**Negligible**
		Direct: The use of heavy machinery during construction and well drilling may generate localized vibrations sufficient to harm ground-dwelling rare and endemic wildlife species.	Small	**Minor-Moderate**	Conduct pre-clearing survey and relocate any rare or endemic species found onsite prior to drilling activities.	**Negligible**

Receptor	Sensitivity	Impact	Magnitude	Pre-mitigation Impact Significance	Mitigation Measures	Residual Impact Significance
		Indirect: Operation of the drill rig and blow testing would create noise (see Section 5.2.2), causing displacement of rare and endemic species from the drill sites and the surrounding vicinity, which would modify wildlife use of the affected area and temporarily fragment habitat. Noise would also interfere with inter-specific communication, particularly for rare and endemic birds that use vocalizations to communicate with other individuals occurring in nearby and distant habitats. Artificial lighting would create disturbance and displacement of light-sensitive rare and endemic animal species and lights could act as attractants for night-migrating or nocturnal species, increasing the potential for collision with lighting structures, increased energy expenditure, or increased predation.	Medium	**Moderate-Major**	Initiate drilling and steam blow testing prior to the onset of the St. Vincent parrot breeding season (January) to the maximum extent possible. Implement the noise mitigation measures defined in Section 5.2.2. Minimize the amount of artificial lighting used at the pad sites and use directional lighting (downward facing lighting).	**Minor**
		Indirect: Project-related influx of workers and improved road access to La Soufrière could increase hunting/collection pressure for St. Vincent parrot, a species that is already targeted by the illegal wildlife trade.	Negligible-Small	**Minor**	Implement and enforce strict no hunting and freshwater fishing policy for project workers.	**Negligible**
Protected Areas	High	**Indirect:** Project-related activities would result in the temporary degradation of habitat quality within the protected areas immediately adjacent to the pad sites including La Soufriere National Park and Mount Pleasant Forest Reserve.	Negligible-Small	**Minor**	Minimize the footprint of the Project to ensure no spillover of Project activities occurs in the protected areas. Implement the noise mitigation measures defined in Section 5.2.2 and the lighting minimization procedures defined above.	**Negligible**

5.3.2.1 *Overview of Key Terrestrial Biodiversity Impacts*

The most significant Project impacts on terrestrial biodiversity relate to direct mortality or injury of any rare or endemic species and indirect impacts on wildlife, particularly rare and endemic species, related to noise generated during the exploratory drilling and blow testing activities.

Rare and endemic plants that occur on the exploration drill pad and injection pad sites would be removed or subject to damage from ground disturbing activities and accumulation of dust. Wildlife that is unable to flee from the activity sites during site preparation activities, particularly sessile species such as the St. Vincent whistling frog, which is listed as Endangered by IUCN, is a local endemic species and occurs at exploration drill pad W1, could be killed or injured during site clearing activities. The whistling frog occurs throughout forested and agricultural habitats on La Soufrière Volcano, however, and the site does not support a concentration or subpopulation of the species. So while impacts to individuals of this species from the Project are possible, they are not likely to have substantial population level effects despite the species' Endangered status because they would only affect a very small proportion of the species' range and population. The population status of this species is declining, however, so any impacts to individuals have the potential to have *Minor*, localized subpopulation effects. Based on the receptor sensitivity and the magnitude of the impact, the pre-mitigation significance rating of this impact is *Moderate*.

Localized wildlife disturbance and displacement would occur as a result of the human activity, light, noise, and vibrations during site preparation, exploratory drilling, and blow testing. Of all the impact sources generated by the Project, noise generated during drilling and steam blow testing activities has the greatest potential to adversely affect wildlife because of its magnitude and duration, which would encompass at least one reproductive cycle and be carried out 24 hours per day. Figures 5-4 through 5-9 (noise contour maps) depict the estimated noise levels at various distances from Project activities. These figures show that the noise is expected to be high (greater than 75 dBA) on and immediately adjacent to the exploration drill pad and injection pad sites, but dissipate rapidly toward *Small* to *Negligible* levels (45 dBA or less) at distances less than 500 m from the sites (see Section 5.2.2). Thus, the total area affected by significant levels of noise encompasses a very small proportion of the wildlife habitat on La Soufrière Volcano.

Birds are generally more susceptible to noise than other terrestrial taxa groups because they rely so heavily on auditory cues and vocalizations for attracting mates, communicating threats, etc. The response to noise by birds varies considerably by species but in general, large-bodied birds such as parrots and raptors are more susceptible to noise disturbance than small songbirds (Ortega

2012). It is expected that the noise generated by the Project during exploratory drilling and well testing would displace birds and other wildlife from areas where noise is well above current ambient conditions (generally within 500 m of the well and injection pad sites). Displacement can cause affected individuals to lose access to forage, access to mates, or dependent young. It would also increase intra- and inter-specific competition in areas to which displaced individuals move. The highest levels of noise, which would be experienced very close to the Project sites, could cause nest abandonment by birds if noise-producing activities are initiated after the onset of the breeding season, which starts in January for many species on St. Vincent. If the disturbance occurs late in the breeding season, individuals may not reattempt to nest following disturbance, resulting in the loss of a full breeding year for the affected species in a given area. If the disturbance occurs early in the breeding season, individuals could reattempt to nest elsewhere if suitable habitat exists and it is not already occupied by other individuals. If the new habitat is suboptimal, reduced adult and immature bird survivorship, reduced reproductive rates, or reduced offspring survivorship could occur.

The primary species of concern with respect to noise impacts from the Project is the St. Vincent parrot because the species is known to inhabit the forested ridges on each side of the Project Area and regularly use the Project Area as a movement corridor between nesting and foraging habitats. No published papers contain any data on the response of parrots to noise or the effects of noise on parrot behavior, reproductive success, etc. However, anecdotal information from parrot experts and from observing parrots in captivity indicates that parrots would be displaced from the general Project Area and vicinity for the duration of the Phase I activities. Further, noise generated by the Project would interfere with inter-specific communications as parrots use vocalizations to communicate with mates, competitors, etc. The affected area is a very small proportion of the parrot's habitat on La Soufrière Volcano, but individuals that are displaced could lose a full recruitment year if the disturbance causes them to abandon nests or skip nesting altogether for a season. Based on the receptor sensitivity and the magnitude of the impact, the pre-mitigation significance rating of this impact is *Moderate*.

Working hours during the Phase I activities would be 24 hours a day, 7 days a week and therefore, use of artificial lighting would be necessary. Artificial lighting would produce an envelope of unnatural light around facilities and result in the disturbance or displacement of light-sensitive species from within this envelope. The Project Area is naturally dark and has very few artificial light sources so introduction of light as a result of the Project would disturb and possibly temporarily displace light-sensitive species at and in the immediate vicinity of the pad sites. Where displacement occurs, it can result in the functional loss of habitat, decreased carrying capacity of habitats, and increased energy expenditure of affected individuals (Platteeuw and Henkens 1997). The degree of disturbance and displacement experienced by wildlife depends on the season and life stage when the impact occurs, as well as the sensitivities of individuals and species to disturbance impacts.

Artificial lighting can have significant impacts on bats and night-migrating birds because the lights can cause confounded navigation, changes in inter- and intra-specific competitive interactions, altered predator-prey relations, and various effects on animal physiology (Gaston *et al.* 2013). Introducing artificial lighting into an area with minimal or no artificial lighting can have significant impacts on bats and night-migrating birds because they act as attractants. Birds and bats can collide with lighting structures and lights can confuse migrating species, particularly when there is low cloud cover or otherwise obscured view of the night sky that birds use to navigate during nocturnal migration (Rich and Longcore 2006). Birds lose their stellar cues for nocturnal navigation under low cloud ceiling or other adverse weather conditions and in these circumstances artificial lights become the strongest cues that birds have for navigation. As a result, they are attracted to the lights and would fly around them for extended periods, a phenomenon which is referred to in the scientific literature as the "trapping effect" during which birds can collide with the lighting structure or other birds, be preyed upon by nocturnal aerial predators (owls), or expend energy needed for long distance migration (Deda *et al*. 2007).

The relatively short-term nature of the Phase I activities and the small number and spatial extent of the Project-related lighting limit the potential for significant population-level impacts for any wildlife species, including rare and endemic species. Based on the receptor sensitivity and the magnitude of the impact, the pre-mitigation significance rating of this impact is *Moderate*.

5.3.2.2 *Overview of Key Freshwater Aquatic Biodiversity Impacts*

The most significant impact on aquatic habitat is the loss of habitat due to extraction of water from the Rabacca River and the loss of continuity between the remaining habitats, particularly at the onset of the wet season when the river is driest. By reducing the volume of water in the Rabacca River, the water withdrawal would reduce the amount of habitat available to aquatic organisms throughout the river and reduce the local populations of aquatic organisms within the river. In addition to reducing the local populations of these species, the Project may also interfere with the migratory life cycles of several species. The migratory shrimps and Sirajo goby fish rely on increased freshwater inputs to the estuarine and nearshore marine zone as a cue to begin migrating upstream to begin the adult phase of their life cycle (Snyder *et al.* 2011). The water withdrawal would decrease the volume of freshwater entering the lower river, thereby reducing the strength of this migratory cue. The gobies and the shrimps require an intact river system for larvae to descend to the coast and juveniles to return to adult habitat and breeding areas upstream. Reducing the flow in the river would expose more area of riverbed and impede passage in both directions for these species. Based on the receptor sensitivity and the magnitude of the impact, the pre-mitigation significance rating of this impact is *Moderate*.

Entrainment and/or impingement of resident and migratory aquatic biota are the most significant potential impact of the Project on aquatic biota. Larval organisms passing by the withdrawal on their downstream migrations may be taken into the pipeline either routed to the water storage pond or injected directly into the wells. Upstream migrants may be more able to escape entrainment, but would still be susceptible to entrainment or impingement on the intake structure. Impinged organisms would not enter the pipeline but may be injured or killed by collisions with the intake structure. Based on the receptor sensitivity and the magnitude of the impact, the pre-mitigation significance rating of this impact is *Moderate*.

5.3.2.3 Recommended Mitigation Measures

Recommended mitigation measures to minimize impacts on terrestrial biodiversity, particularly rare and endemic species, include:

- Minimize the footprint of activities and related ground and vegetation disturbance;
- Implement dust control procedures (e.g., watering) when needed to control dust;
- Conduct pre-clearing surveys prior to site preparation activities to flush wildlife and remove sessile wildlife, particularly rare and endemic species, from the well pad sites and relocate them to other undisturbed locations;
- Implement a Journey Management Plan, including strict enforcement of speed limits and limit nighttime driving;
- Implement the noise controls and mitigation measures defined in Section 5.2.2;
- Implement the air emissions controls and mitigation measures defined in Section 5.2.1;
- Implement and enforce strict no hunting and freshwater fishing policy for project workers; and
- To the maximum extent possible, initiate drilling and testing prior to the onset of the St. Vincent parrot breeding season (January) to temporarily displace breeding birds to other areas and avoid nest abandonment;
- Conduct a St. Vincent Parrot population census in the forests surrounding the pad sites to establish a baseline to monitor the impacts of the Project on this species; and
- Minimize the amount of artificial lighting used at the pad sites and use directional lighting (downward facing lighting) to minimize light spillover to the sky and adjacent habitats.

Recommended mitigation measures to minimize impacts on aquatic habitat loss/fragmentation and entrainment and/or impingement of biota include:

- Implement sediment and erosion control procedures in all work areas;
- Minimize water abstraction during low flow periods;
- Minimize the intake velocity for the water abstraction; and
- Install wedgewire screens to exclude larval organisms from the water intake.

5.3.2.4 *Residual Impact Significance*

Implementation of these measures would reduce the impacts of the Project on terrestrial and freshwater aquatic biodiversity to *Minor* or *Negligible*.

5.4 *SOCIOECONOMIC AND HEALTH IMPACT ASSESSMENT*

This section identifies and assesses the potential Project impacts on the existing socioeconomic environment and community health (including community safety and security). Information within Chapter 3.0, *Description of the Proposed Project,* and Section 4.3, *Socioeconomic and Health Baseline,* were used to assist the evaluation of the potential impacts and their significance. This section has also considered information from other impact assessment sections in order to inform and evidence the subsequent assessment of impacts on socioeconomic and community health receptors, including but not limited to landscape and visual, cultural heritage, and traffic. These sections are cross-referenced where appropriate.

The methodologies specific to socioeconomics and community health presented in this section build upon the general assessment methodology summarized in Section 5.1, *General Methodology*. The general methodology has been tailored to the specific socioeconomic and community health-related impacts arising from Project activities. The social and community health receptors as well as Project activities relevant to this assessment are summarized below. The criteria for the assessment, magnitude, and receptor sensitivity are defined in Tables 5-24, 5-25, and 5-26.

It is important to note that stakeholder engagement is a critical component to socioeconomic and community health impact assessments. The information obtained from stakeholders which is presented in the Project's Stakeholder Engagement Plan (and summarized in Chapter 7.0, *Stakeholder Consultation and Disclosure*), as well as information received from stakeholders during the February 2016 site visit, has informed the vulnerability and magnitude designations for this impact assessment.

5.4.1 *Project Activities and Receptors*

As discussed in the Project Description (see Chapter 3.0), the Phase I activities include:

- Access improvements and transportation activities, which could generate increased traffic and congestion on roads, noise disturbance, influx, physical and economic displacement (that would continue throughout the Project), and potential economic benefits to local communities;
- Drill site preparation, which would generate noise disturbance and potential economic benefits to local communities;
- Drill rig installation and drilling, which would generate noise disturbance;
- Exploratory blow testing, which would also generate noise disturbance; and
- Decommissioning, which would generate increased traffic and congestion on roads.

There are two broad categories of potential receptors that have been identified with respect to the potential socioeconomic and community health impacts of the Project. As described in Section 4.3, *Socioeconomic and Health Baseline*, these categories are Project-Affected Communities and Other Affected Stakeholders.

Project-Affected Communities include:

- Residents and farmers near to exploration drill pads and injection pads W1 and W3;
- Populations in the nearest settlements to the Project area, including Sandy Bay, Overland, Orange Hill (including Waterloo and Tourama), Langley Park (including Chapmans and Basin Hole) and Georgetown; and
- Existing businesses in the nearest settlements to the Project area (e.g., shopkeepers).

Other Affected Stakeholders include:

- People living and working along the 33 km of Windward Highway and feeder roads between Kingstown Port and sites W1 and W3;
- Existing potential workforce (those seeking employment);
- Vulnerable groups (e.g., children, women, elderly, disabled); and
- Local recreational users and foreign tourists at Bamboo Range Hiking Base Station.

Receptors and resources may vary by the type of impact, and different impacts may affect different receptors. A receptor may be an individual, household, group or organization, or a community. Receptors may be affected by changes in the environment, or by changes to aspects such as land use, transportation, livelihoods, incomes, community values, or the enjoyment of natural areas. Accordingly, receptors that could experience a socioeconomic or community health impact in one or more of these ways because of Project activities are identified and assessed in this section.

5.4.2 *Socioeconomic and Health Impact Assessment Methodology*

In this assessment, sensitivity (vulnerability) represents a stakeholder's resilience or capacity to cope with change. There is a range of variables that can influence a stakeholder's sensitivity and should be considered (e.g., age, gender, land rights, employment, livelihood strategies, education). When considering impacts on people, sensitivity is typically a complex interaction of some or all such factors. In order to facilitate a comparison of impacts for the purposes of this ESIA, a series of criteria attempting to capture these elements have been established based on professional judgement and Good International Industry Practice (GIIP).

Also aligned with GIIP, the community health assessment looks at the four "determinants of health" themes:

- Individual (e.g., lifestyle, circumstance);
- Social (e.g., conduct of workforce, spread of disease);
- Environmental factors (e.g., noise impacts from equipment, impacts on road safety due to increased traffic); and
- Institutional factors (e.g., quality and quantity of local health and emergency service).

It is important to note that for socioeconomic and community health impacts, the concept of sensitivity (vulnerability) is a key consideration and reflects the degree of response to a change in baseline conditions by a receptor. This degree of response may range from being very susceptible to change (and having little resilience) to being able to absorb or adapt to change (being very resilient). In many cases, certain subgroups (for example, children, women, the elderly, and disabled peoples) may be disproportionately affected. Therefore, vulnerable groups as a receptor category have been assessed separately.

Table 5-24 outlines the criteria for evaluating sensitivity from *Low* to *High*. The sensitivity of receptors is considered in the context of each individual impact.

Table 5-24: Description of Sensitivity (Vulnerability) Designation for Social and Health Receptors

Sensitivity	Description
Low	• Minimal vulnerability; consequently with a high ability to adapt to changes brought by the Project and opportunities associated with it. • Communities with sufficient coping strategies who feel little or no challenge to their wellbeing as a result of project activities • They may share resources with the project occasionally and broadly understand the hazards associated with project components.
Medium	• Some, but few areas of vulnerability; retain an ability to at least in part adapt to change brought by the Project and opportunities associated with it • They are likely to experience temporary inconvenience as a result of changes in environmental or social determinants of health; They express some concerns and anxieties regarding the impact of the Project on their wellbeing • They have some, but not complete, understanding of the technical hazards associated with project components
High	• Profound or multiple levels of vulnerability that undermine the ability to adapt to changes brought by the Project and opportunities associated with it and very limited coping strategies • Groups who are very young, very old, or disabled may have high sensitivity to changes in environmental health determinants, such as air quality and noise levels. • Groups who are poorer or who have lower social status have high sensitivity to changes in social health determinants because they have less access to medical care, complaint procedures; or political representatives. • They may be marginalized

The magnitude of an impact is a measure of the degree of change in the baseline environment as a result of the Project. This baseline could refer to a diverse range of factors affecting individual receptors (i.e., financial, physical, or emotional). The dimensions affecting magnitude include the duration, frequency, reversibility, and extent of an impact. The determination of impact magnitude for adverse impacts is also based on a scale of *Negligible* to *Large*.

Table 5-25: Description of Magnitude Designation for Social and Health Receptors

Magnitude	Description
Negligible	Change remains within the range commonly experienced within the household or community
Low	Perceptible difference from baseline conditions; Tendency is that impact is local, rare, and affects a small proportion of households and is of a short duration
Medium	Clearly evident difference from baseline conditions. Tendency is that impact affects a substantial area or number of people and/or is of medium duration. Frequency may be occasional and impact may be regional in scale.
Large	Change dominates over baseline conditions. Affects the majority of the area or population in the Area of Influence and/or persists over many years. The impact may be experienced over a regional or national area.
Positive	In the case of positive impacts, it is generally recommended that no magnitude be assigned unless there is ample data to support a more robust characterization. It is usually sufficient to indicate that the Project would result in a positive impact, without characterizing the exact degree of positive change likely to occur.

Table 5-26: Designating Significance Ratings for Social and Community Health Impacts

		Sensitivity/Vulnerability/Importance of Resource/Receptor		
		Low	**Medium**	**High**
Magnitude of Impact	**Positive**	Positive	Positive	Positive
	Negligible	Negligible	Negligible	Negligible
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Major

A range of potential impacts have been scoped out on the basis that the impacts would be *Negligible* and, therefore, further mitigations are not required. These are described in Tables 5-27 and 5-28.

Table 5-27: Scoped Out Social Impacts

Impact	**Reason for Scoping Out**
Increased pressures on local water use	The Rabacca River is not commonly used by social receptors for drinking water or irrigation, and therefore is unlikely to be of any level significance to generate negative impacts on social receptors.
Reduced availability for fishing and hunting	Fishing and hunting are not common activities in the Project Area, and therefore are not expected to be adversely affected in any significant way by Project activities.
Impacts to Indigenous Peoples	There are no classified Indigenous Peoples in the Project Area.

Table 5-28: Scoped Out Community Health, Safety and Security Impacts

Impact	**Reason for Scoping Out**
Impacts on mental health facility residents	The mental health facility located within the Project area would be relocated (as part of a government program independent of this Project) prior to commencement of construction activities.
Potential changes to ecosystem services resulting in adverse community health and safety impacts, such as impacts to slope stability and flooding potential	Project activities are not expected to impact these ecosystem services to the extent of causing community health and safety concerns (see Section 5.2.3, *Soils and Geomorphology*, for further details).
Stress on local medical facilities	Since peak employment during drilling activities would be 40 people, it is not expected to add significant stress on existing medical facilities.

The Project is not considered high risk from a socioeconomic standpoint and there are no significant socioeconomic triggers that would necessitate a separate Human Rights Impact Assessment. With regards to the potential risks for Human Rights, there were no significant adverse potential impacts identified that would not be mitigated through adherence to existing policies, plans and procedures, as well as through community engagement and implementation of the community grievance mechanism.

It has been assumed that the consideration of the potential health and safety impacts to the Project's workforce would be taken care of through the Project's Occupational Health and Safety standards and guidelines, which the Drilling Contractor will be required to comply. This is also the case for Emergency and Disaster Response.

5.4.3 Socioeconomic and Health Impacts Discussion

Below is a discussion of 1) the array of socioeconomic and community health, as well as, safety and security benefits and impacts expected; and 2) these benefits and impacts by social receptor.

5.4.3.1 Economic Benefits

The primary benefits of the Project include employment generation and increased demand for goods and services. In terms of the workforce directly hired by the Project, all workers contributing to civil works elements during the access improvements and transportation activities (10 to 15 workers) would be sourced from the local community. The construction of auxiliary facilities would employ local workers as supporting staff (e.g., drivers, flagmen). During the drilling activities, 30 percent of the total 30 to 40 workers contributing to drilling activities (9 to 12 workers) would be sourced from the local community.

In addition to any potential direct employment generated by the Project itself through the contractor, there would be an increase in local employment arising from indirect and induced effects of the Project activities. Indirect employment includes the procurement of goods and services from local businesses that could generate an increase in jobs with these businesses. Employment growth may therefore indirectly arise locally or create employment multiplier effects; however, this effect would not be large.

In terms of indirect economic impacts, worker accommodations would be located at nearby communities for a period of 7 to 12 months where rooms and houses would be rented, which would result in the generation of additional income for local residents in the Project-Affected Communities.

However, there is the potential for negative sentiment generation within the community in relation to the employment of non-local labor. Specifically, this may arise relating to:

- Unfulfilled local employment expectations and resentment between local people who are employed by the Project and those who desire jobs but have not been hired, and between local and non-local workers if local people perceive that foreign workers are receiving better pay or conditions for the same job;

- Unfulfilled skill development and training expectations as the positions to be filled by workers local to the area are likely to be unskilled/semi-skilled) and short term, and training of local workers associated with the Project – if it occurs – would be limited to the training required for these unskilled (or potentially semi-skilled) positions; and
- Increased tensions within the local communities over access to jobs and due to the presence of non-local workers in the area.

5.4.3.2 Physical Resettlement

In terms of physical resettlement, according to the Resettlement Action Plan (RAP) (Geothermal Consortium 2015a) only one household is planned to be physically resettled as a result of Project activities occurring at exploration drill pad W3 (see Figure 5-10). While the new housing site has been confirmed and construction has commenced (see Figure 5-11), this new location is now within or near the W3 injection pad site estimated location, which is likely not an appropriate location , assuming the W3 site is actually developed, as the area would be significantly impacted by noise. As Project activities and the RAP are finalized, the significance of this potential impact should be reassessed.

Figure 5-10: House to be Relocated

Figure 5-11: New Relocation Site

5.4.3.3 *Economic Displacement*

In terms of economic displacement, according to the RAP (Geothermal Consortium 2015a) three households that own three land parcels for agricultural farming (primarily banana plantations) would be affected by Project land use and these agricultural activities would need to be relocated and the families compensated. Although not covered in the latest version of the RAP, it is highly likely that other farmers owning, using, or leasing land within the Project area would be affected by the following Project activities:

- Land clearing where drill pads and injection pads would be located;
- Land for water system;
- Water storage and pipelines; and
- Potential expansion and /or widening of existing roads.

Furthermore, as discussed below, noise levels as a result of drilling and exploratory blow testing activities would impact areas beyond those potentially acquired for the Project, which may result in additional physical or economic displacement (see Section 5.2.2, *Noise*). As noted with Physical Resettlement, this has not yet been confirmed and once Project activities are finalized and the RAP is updated, the significance of this potential impact should be reassessed.

5.4.3.4 *Noise*

The most significant impact on socioeconomic and health receptors as a result of Project activities is expected to be a result of noise generation in the Project Area over an extended period of time (approximately 7 to 12 months). Specific noise data and assessments of thresholds for receptors can be found in the Section 5.2.2, *Noise*. The sensitivity of receptors to noise is primarily dependent upon the activities that occur at the receptor location. For example, locations where people rest or sleep are considered to be more sensitive to noise than agricultural areas. Typically, noise impacts (particularly if occurring at night) may detract more from the quality of life for individuals than noise impacts during the day. The overall sensitivity of residents to noise-related impacts for this assessment is generally considered to be *Medium* during the day and *High* at night, except for recreational areas, medical institutions, and residential properties, which remain *High* day and night.

As shown in Figures 5-4 to 5-9 in Section 5.2.2, *Noise*, noise would exceed the daytime IFC standard for ambient/ airborne noise levels (55 dBA) up to approximately 200 m from the center of the drill and injection pad locations. As a result, farmers working in the fields within these exceedance zones during the day would be negatively impacted (see Economic Displacement Section). Since it appears that agricultural land would still remain in use in these zones, once the drill rig is up and operating, the Project would need to provide workers with appropriate noise protection and/or consider relocating the farming activities to other lands outside of the Project-Affected areas.

Noise would exceed nighttime IFC standard for ambient/ airborne noise levels (45 dba) up to approximately 500 m from the center of the exploration drill pad and injection pad locations during drilling activities. However, for the sake of this assessment, it is assumed that any people residing within noise threshold exceedance zones (including the potential new resettlement site) would be physically relocated and farmers within these zones do not work at night. Therefore, night thresholds do not apply for this assessment.

The only documented residence is within drill site W3, and this residence is currently being relocated adjacent to injection pad W3 as per the RAP (see Section 5.4.3.2, *Physical Resettlement*, above). However, as indicated above, the new location would be affected by similar noise impacts as the original residence as both are within the daylight threshold exceedance zone, and therefore secondary resettlement would need to be reconsidered by the Project and the RAP adjusted accordingly.

It is important to note that the noise assessment used the locations of the exploration and injection pads provided by SVGCL; if these locations change, the noise contour estimates need to be updated.

Noise as a result of traffic would be minimal for Project and Other Affected Communities because of relatively low traffic volumes.

5.4.3.5 *Influx*

Influx may result from increased expectations around Project activities, such as the expectation of employment as discussed above. During informal stakeholder engagement sessions in February 2016, many residents and business owners in Project-Affected Communities cited that many individuals from outside these communities could enter the area seeking opportunity for employment and informal selling of goods (e.g., crops), and that crime may result from this influx of people into the Project Area. Considering the fact that marijuana cultivation also employs individuals in the Project Area and on the slopes of the La Soufrière Volcano, marijuana growers could view an increase in foreign workers in the Project Area as an opportunity to attract new business.

An increase in prostitution around Project sites and accommodations where foreigners are residing for extended periods is common on construction projects. While local police did not express a concern (citing that most prostitution occurs in Kingstown), local health officials did indicate that sex workers would likely see the Project as an increased opportunity for income. This could result in an increase in communicable disease rates amongst both foreign and local populations.

5.4.3.6 *Tourism*

The Project could affect recreational use at Bamboo Range Hiking Base Station, the location where hikers ascend La Soufrière Volcano, as a result of increased noise. As shown in Section 5.2.2.5, *Predicted Noise Levels at Closest Receptor Locations*, noise would not exceed the daytime threshold (55 dBA) at the location of the Station; however, the peaceful nature of the facilities located at the trailhead (including rest areas) would be impacted by an increase in noise. The trail is not utilized at night and therefore the nighttime threshold would not be relevant.

If not properly managed, this impact could have negative implications for the nation's tourism industry, given that one of the most popular tourist attractions on the main island is the La Soufrière Volcano. In Phase I, SVGCL can provide signage to inform tourists of the future geothermal development project.

The road improvements that would be required for the Windward Highway between the Rabacca River and Orange Hill Settlement and for the W1 feeder road that leads to Bamboo Range Hiking Base Station would improve hiker access. At present, these roads are not able to comfortably accommodate tour buses or several vehicles at a time due to the poor road conditions. The road improvements as a result of the Project were cited by tour guides during the February 2016 informal interviews as the primary benefit of the Project on their work and tourism in the area.

5.4.3.7 *Traffic*

As noted in Chapter 3.0, *Description of the Proposed Project*, SVGCL identified that road improvements are required for the Windward Highway between the Rabacca River and Orange Hill Settlement and for the two feeder roads. Improvement of the Windward Highway would involve cutting back embankments and curves. Improvement of the feeder roads would involve widening of curves and/or construction of drainage works.

Traffic both along the feeder roads W1 and W3 and along the main highway would increase during these activities. Traffic accidents involving both vehicles and pedestrians from Project and Other Affected Communities may occur as a result of increased traffic. This is because the main highway does not have sidewalks (yet is frequently used by pedestrians). The feeder roads are also poor quality, but are less frequented by pedestrians and vehicles. As stated in Section 5.5, impacts are expected to be *Moderate* during the access improvements and transportation and decommissioning phases, when additional traffic would be heaviest along the highway. This has the potential to create community health and safety impacts, especially for vulnerable groups.

5.4.4 *Socioeconomic and Health Impact Summary*

Table 5-29 below provides a summary of the socioeconomic related impacts, and Table 5-30 provides a summary of community health, safety, and security related impacts, according to receptor. Within the respective impact assessments, a set of receptor-specific mitigation measures and project controls and mitigation measures have been identified. It is assumed these mitigations and controls would be put in place by the Project, and therefore the impact assessment takes these into consideration when defining the sensitivity and magnitude to derive residual impact significance.

Table 5-29: Socioeconomic Impacts by Receptor

Receptor(s)	Impact (Activity Phase)	Sensitivity	Magnitude	Pre Mitigation Significance	Mitigation Measures	Residual Significance
Residents and farmers near to exploration drill pads and injection pads	**Physical resettlement** (All activity phases)	Medium	Large	**Major**	Resettlement Action Plan (revised to include secondary resettlement location) Community Grievance Mechanism	**Moderate**
	Economic displacement (All activity phases)	Medium	Large	**Major**	Livelihood Restoration Plan / Resettlement Action Plan Community Grievance Mechanism	**Moderate**
	Stress on local infrastructure (housing, businesses) (During drill rig installation and drilling; and exploratory blow testing phases)	Low	Medium	**Minor**	Community Grievance Mechanism Local Employment and Supplier Development Plan Explore use of former temporary mental hospital (to be relocated prior to Project start-up) as temporary Project accommodations Liaise with Ministry of Housing to assist in seeking suitable accommodations and setting rental rates to not drive up other costs in Project area	**Negligible**
Populations in the nearest settlements to the Project area	**Stress on local infrastructure (housing, businesses)** (During drill rig installation and drilling; and exploratory blow testing phases)	Low	Medium	**Minor**	See Stress on Local Infrastructure Project Controls above	**Negligible**

Receptor(s)	Impact (Activity Phase)	Sensitivity	Magnitude	Pre Mitigation Significance	Mitigation Measures	Residual Significance
Existing potential workforce in Project-affected communities	**Economic benefits** (During access improvements and transportation; drill rig installation and drilling phases)	Positive	Positive	**Positive**	Local Employment and Supplier Development Plan Share Local Employment and Supplier Development Plan transparently with Project and Other Affected Communities to manage employment expectations Ensure Drilling Contractor adheres to the Local Employment and Supplier Development Plan	**Positive**
Existing businesses in the towns	**Economic benefits** (During access improvements and transportation; drill rig installation and drilling phases)	Positive	Positive	**Positive**	See Economic Benefits Project Control above	**Positive**
Local and foreign tourists at Bamboo Range	**Tourism and loss of recreational amenity** (During access improvements and transportation; drill rig installation and drilling phases)	Medium	Medium	**Moderate**	Ensure Traffic Management Plan includes continued daytime access to the Bamboo Range trailhead Create interpretative and educational signage at Bamboo Range related to Project activities Develop plans with Ministry of Tourism for tours of Project site (if feasible) and generate positive sentiment amongst tourists about the environmental advantages of geothermal power Carry out road improvements on W1 Feeder Road up to Bamboo Range Hiking Base Station Implement monitoring plans which track and evaluate data on tourist experience in relation to Project impacts	**Minor**

Table 5-30: Community Health, Safety and Security Impacts by Receptor

Receptor(s)	Impact (Activity Phase)	Sensitivity	Magnitude	Pre Mitigation Significance	Project Controls	Residual Significance
Residents and farmers near to exploration drill pads and injection pads	**Noise** (During drill rig installation and drilling; and exploratory blow testing phases)	Medium	Medium	**Moderate**	See Section 5.2.2.7 for Noise Mitigations Noise Management Plan, to include monitoring system to identify any exceedances of international standards and requirement for a Corrective Action Plan if standards are exceeded. Provide day farmers with noise protection and/or consider relocation lands	**Moderate**
	Traffic (During access improvements and transportation and decommission phases)	Medium	Low	**Minor**	Traffic Management Plan; Journey Management Plan Ensure that movement of 'outsize' or 'large/long' vehicles, or convoys, would be timed, where practicable, to avoid busy traffic periods and would be restricted to the agreed access routes Implementation of safe driving protocols Emergency Response Plan	**Minor**

Receptor(s)	Impact (Activity Phase)	Sensitivity	Magnitude	Pre Mitigation Significance	Project Controls	Residual Significance
	Increase in crime, prostitution, and conflict as a result of influx (During access improvements and transportation; drill rig installation and drilling phases)	Low	Medium	**Minor**	Implement Community Grievance Mechanism Evaluate need of security guards, fencing, roving police patrols of Orange Hill Code of Conduct for all Project employees and contracted staff including zero-tolerance policy for drug use, sale or purchase Project would issue a policy statement regarding sexually transmitted infections including HIV/AIDS, and this policy would be communicated internally to staff, and externally to Contractors	**Negligible**
Populations in the nearest settlements to the Project area	**Noise** (During drill rig installation and drilling; and exploratory blow testing phases)	Medium	Low	**Minor**	See Noise Project Controls above	**Minor**
	Traffic (During access improvements and transportation and decommission phases)	Medium	Low	**Minor**	See Traffic Project Controls above	**Minor**

Receptor(s)	Impact (Activity Phase)	Sensitivity	Magnitude	Pre Mitigation Significance	Project Controls	Residual Significance
	Increase in crime, prostitution, and conflict as a result of influx (During access improvements and transportation; drill rig installation and drilling phases)	Low	Medium	**Minor**	See Influx Project Controls above	**Negligible**
Populations residing and working along Windward Highway from Project area to Port	**Traffic** (During access improvements and transportation and decommission phases)	Low	Medium	**Minor**	See Traffic Project Controls above	**Negligible**
Vulnerable Groups (elderly, children)	**Traffic** (During access improvements and transportation and decommission phases)	High	Low	**Moderate**	See Traffic Project Controls above Targeted traffic awareness campaigns at schools and churches within Project-Affected Communities	**Moderate**

5.5 TRAFFIC AND VISUAL IMPACT ASSESSMENT

5.5.1 Traffic Assessment

The movement of Project equipment and materials to the island of St. Vincent, as well as from Kingstown Port to the Project site, may create potential interactions between the public and Project-related traffic, as well as the potential for delays and reduced public access. This section evaluates the significance of those potential impacts.

The receptors for transportation and traffic impacts are individuals who use the affected portions of the island's existing transportation system, particularly Kingstown Port, the Windward Highway, and the feeder roads that provide Project site access (as well as access to the Bamboo Range Hiking Base Station and trails). Drivers, cyclists, pedestrians, and (in the case of Kingstown Port) vessel operators are all potential receptors.

The Project would require the movement of approximately 70 standard 12 m shipping containers (Nippon Koei *et al.* 2015). Two types of Project activities could create traffic and/or transportation impacts: the use of Kingstown Port for the offloading of these containers, and the movement of those containers from the Port to the Project site via Windward Highway.

5.5.1.1 Traffic Impact Assessment Methodology

The significance of traffic and transportation impacts are determined by comparing the level of receptor sensitivity against the magnitude of the impacts themselves. Table 5-31 summarizes receptor sensitivity, Table 5-32 summarizes levels of magnitude, and Table 5-2 provides the impact matrix used to determine significance.

As described in Section 4.3.9, *Transportation and Traffic*, little quantitative data (such as traffic counts or crash data) are available for St. Vincent or the Project Area. As a result, the description of traffic conditions, and especially the evaluation of traffic impacts, is largely qualitative in nature.

Table 5-31: Receptor Sensitivity Designation for Traffic and Transportation

Sensitivity	Description
Low	Receptors (typically non-project drivers, cyclists, or pedestrians) are readily able to adapt to Project-related changes in traffic volumes and patterns, and/or are not vulnerable to reductions in transportation safety.
Medium	Receptors can adapt to some, but not all, Project-related changes in traffic patterns and transportation safety. Some receptors (e.g., those who must walk along public roads to reach markets or schools) are especially sensitive to degraded traffic safety conditions.
High	Receptors are unable to adapt to changes in traffic patterns and transportation safety without notable threats to health and/or safety. Substantial portions of the population are isolated or otherwise vulnerable to degraded traffic safety conditions.

Table 5-32: Magnitude Designation for Traffic and Transportation

Magnitude	Description
Negligible	Changes in traffic congestion, traffic volumes, crashes, and/or injuries are not readily noticeable (or no change occurs).
Small	Increase in traffic congestion and/or traffic volumes that, while notable, does not require a change in daily travel patterns. Increase in crashes and injuries may or may not be notable.
Medium	Notable increase in traffic congestion and/or volumes requiring changes in daily travel patterns. Increase in the number and/or severity of traffic crashes and injuries, but not to the point where medical service capacity or individual livelihoods suffer notably.
High	Dramatic increase in traffic congestion and/or traffic volumes, to the point where daily travel patterns are substantially altered. Dramatic increase in the number and/or severity of traffic crashes and injuries (including deaths), to the point where livelihoods are altered and/or the capacity of emergency response capacity is strained.

5.5.1.2 Traffic and Transportation Impact Discussion

The Project would generate several potential traffic and transportation impacts, each of which is discussed below. Table 5-33 summarizes the significance of these impacts.

5.5.1.2.1 Impacts on Port Capacity

The Project's 70 12-m containers represents a small fraction of the nation's annual cargo volume (approximately 23,000 containers), and presumably represents a comparably small fraction of the cargo activity at Kingstown Port. While the Project would represent a marginal increase in port activity, this increase would be essentially imperceptible for commercial vessels making calls at Kingstown Port, as well as other vessels in the waters around Kingstown Port.

Port officials have indicated that Kingstown Port could receive and store the containers associated with the Project (Stantec 2015). As a result, there would be a *Negligible* impact on port capacity.

5.5.1.2.2 Impacts on Road Capacity and Congestion

Specific estimates of Project-related traffic and existing road traffic are not available. The Project would generate traffic associated with the movement of equipment and personnel to the Project site during drill pad construction, as well as during cargo container movement from Kingstown Port. The Project would likely employ fewer than 100 workers at any one time.

Movement of shipping containers, earth-moving equipment, and/or other larger Project components would be rare (i.e., once at Project initiation, once at Project completion), but could increase traffic congestion during those moves, due in large part to the difficult terrain that the Windward Highway traverses.

The Ministry of Transport and Works has stated that a Journey Management Plan will be required for the contractor to ensure that equipment is transported from the port early in the morning and/or on weekends to avoid peak hours. In particular, the Ministry recommends no activity before 10 a.m. or after 2 p.m. on weekdays (Bailey 2016). With these limitations, "it is expected that the transport of equipment will take several days" (Nippon Koei *et al.* 2015). Traffic would return to normal volume and operation once large-vehicle movements are complete. The number of recurring vehicle trips associated with Project employees or other regular trips (such as delivery of supplies) would be unlikely to change traffic capacity or congestion on Windward Highway.

With the above-described Project controls in place and enforced, there would be *Minor* impacts on road capacity and congestion.

5.5.1.2.3 Impacts on Road Infrastructure

The movement of tracked construction vehicles (i.e., earthmoving equipment), and to a lesser degree other Project traffic, could damage road surfaces. The Ministry of Transport and Works has requested direct involvement in planning for the movement of such equipment. ERM assumes that the Journey Management Plan would serve this purpose. That plan, along with requirements to transport tracked vehicles via trailer when possible, would result in no more than minor impacts to road infrastructure.

As described in Section 3.3.1, *Access Improvements and Transportation*, the Project would result in minor improvements to Windward Highway north of the Rebacca River, primarily to allow passage of large vehicles on sharp curves. The feeder roads would also be widened and/or would have upgraded drainage.

To the extent Project activities damages any roads, SVGCL would be expected to provide funding for necessary repairs.

5.5.1.2.4 Impacts on Transportation Safety

Users of Windward Highway would experience an increased safety risk due to Project-related large vehicle movements. This risk would be highest for pedestrians and cyclists because there are essentially no sidewalks or pedestrian paths along Windward Highway. Pedestrians (including schoolchildren) must use the road to walk between home, school, and other locations. The combination of large Project-related vehicles, challenging road geometry, and unprotected pedestrians could result in increased risk of injury.

As described above, a Journey Management Plan would limit large vehicle movements to the middle of the day, when children are in school and workers are at their place of employment. In addition, that plan should require the use of escort vehicles for movements of cargo containers and other large equipment (Nippon Koei *et al.* 2015).

With those project controls in place, the magnitude of impacts to transportation safety would be *Small*, resulting in an overall *Moderate* impact.

Table 5-33: Traffic and Transportation Impacts

Impact	Receptor	Sensitivity	Magnitude	Mitigation Measures	Residual Significance
Port capacity	Commercial port users, vessels in waters near Kingstown Port	Low	Negligible	None	Negligible
Road capacity and congestion	All road users	Medium	Small	Journey Management Plan requiring off-peak trip scheduling	Minor
Road infrastructure	All road users	Medium	Small	Journey Management Plan requiring trailer transport of tracked vehicles Provide funding to repair road damage caused by Project activities	Minor
Transportation safety	All road users, specifically pedestrians and cyclists	High	Small	Journey Management Plan requiring use of escort vehicles	Moderate

5.5.2 *Visual Resources*

Project activities would change the visual appearance of two exploration areas near recreational and scenic resources considered important by St. Vincent residents and tourists. This section evaluates the significance of those potential visual impacts.

The receptors for visual impacts are individuals who could have clear views of the Project site, equipment, and activities from publicly accessible places. In particular, receptors include individuals using the Bamboo Range trails and base station, as well as those who journey to the summit of La Soufrière Volcano.

Specific project activities with the potential to generate visual impacts include the clearing and grading of land for drill pad sites, as well as the placement of drill rigs (whose mast would extend 20 to 25 feet above ground level). The presence of Project workers and vehicles in an area where they would not previously have been expected could also constitute a visual and recreational experiential impact. Well testing, which involves plumes of steam, could also change the visual environment.

5.5.2.1 *Visual Impact Assessment Methodology*

The significance of visual impacts are determined by comparing the level of receptor sensitivity against the magnitude of the impacts themselves. Table 5-34 summarizes receptor sensitivity, Table 5-35 summarizes levels of magnitude, and Table 5-2 provides the impact matrix used to determine significance.

Table 5-34: Receptor Sensitivity Designation for Traffic and Transportation

Sensitivity	Description
Low	Viewers are in a location where high scenic quality is not expected, such as in an urban area or on inland portions of Windward Highway.
Medium	Viewers are in a location where high scenic quality is occasionally expected, such as coastal portions of Windward Highway (i.e., where large expanses of coastline may be visible) or on the Bamboo Range trail system.
High	Viewers are in a location where high scenic quality is expected, such as at the summit of La Soufrière.

Table 5-35: Magnitude Designation for Traffic and Transportation

Magnitude	Description
Negligible	Changes in visual conditions are not readily noticeable (or no change occurs).
Small	Changes in visual conditions are perceptible, but do not notably detract from the overall visual experience.
Medium	Changes in visual conditions are perceptible and detract from the overall visual experience to some degree.
High	Changes in visual conditions are dramatic, and entirely change or even remove all enjoyment of the overall visual experience.

5.5.2.2 *Visual Impact Discussion*

Visitors to the Bamboo Range Hiking Base Station would pass by the W1 injection site, drill pad, and water storage pond, and would be within 500 m of the similar W3 facilities. The degree to which Project sites and equipment (including drill rigs and masts) would be visible to visitors depends on the exact placement of drill rigs and other Project components, as well as the amount of vegetation is retained at the edge of Project sites.

Project sites would not be visible from the Bamboo Range trails themselves, or from the summit of La Soufrière Volcano, due to dense tropical vegetation. As shown in the view from the summit (see Figure 4-49), viewers would be able to see long distances, but that foreground areas such as the slopes of the volcano are blocked by vegetation. While steam plumes could rise above the canopy, the density of existing vegetation makes it unlikely that visitors would see these plumes once on the trail.

The Bamboo Range Hiking Base Station is an area of *Medium* visual sensitivity: visitors to the Bamboo Range trails likely expect high quality scenery along the trails themselves, but do not necessarily expect such conditions at the base station. Assuming a minimum of vegetative screening (a conservative assumption, absent site-specific layout information), the magnitude of visual impacts would be *Medium*: the presence of drilling activity would be a notable change in visual conditions, and would likely detract from the visual experience to some degree.

As a result, the Project should retain vegetation at the edge of drill and injection pads, as well as water storage ponds, to screen these facilities from view from the Bamboo Range access road. Such screening would reduce the visual impact magnitude to *Small*, and would therefore result in *Minor* visual impacts (see Table 5-36).

Table 5-36: Visual Impacts

Impact	Receptor	Sensitivity	Magnitude	Mitigation Measures	Residual Significance
Visual impacts	Visitors to Bamboo Range base station and trails	Medium	Small	Retention of vegetation at pad edges, for visual screening	Minor

5.6 *CULTURAL HERITAGE IMPACT ASSESSMENT*

The importance or sensitivity of cultural heritage resources is determined through a combination of their scientific, historical, and/or cultural importance to local, national, and international cultural heritage stakeholders. SVG has two principal cultural heritage laws, the *Saint Vincent and the Grenadines National Trust Act*, Cap. 329, and the *Preservation of Historic Buildings and Antiquities Act*, Cap. 247. These two acts define the types of cultural heritage resources protected under SVG law; establishes the SVG National Trust (NT) as the statutory body responsible for the protection of cultural heritage resources; and requires the SVG NT to maintain lists of protected cultural heritage resources. Resources included on these lists cannot be developed, damaged, or modified without a grant of permission from the responsible government Minister.

In addition to national legislation, IFC Performance Standard (PS) 8 provides guidance on assessing cultural heritage resource sensitivity and is generally viewed as good international industry practice. IFC PS 8 establishes three IFC-specific resource categories, each with associated mitigation approaches. The categories are:

- **Replicable cultural heritage resources** – forms of cultural heritage that can be relocated or replaced with an associated transfer of cultural value or archaeological or historical sites whose cultural values are well represented by other sites or structures;

- **Non-replicable cultural heritage resources** – those that are relatively unique for the period they represent and/or where their cultural value is not transferable; and
- **Critical cultural heritage resources** – internationally recognized heritage of communities who use, or have used within living memory, the cultural heritage for long-standing cultural purposes and legally protected cultural heritage areas, including those proposed by host governments for such designation.

Although not specifically developed to assess cultural heritage resource sensitivity, these categories are often used as a proxy measure for resource importance or sensitivity.

5.6.1 *Cultural Heritage Impact Assessment Methodology*

Based on the national and international criteria described above, Table 5-37 provides a summary of the criteria used to assess cultural heritage resource sensitivity in this analysis.

Table 5-37: Criteria for Determining Cultural Heritage Resource Sensitivity

Sensitivity	Characteristics
Low	Resource is not specifically protected under local, national, or international laws or treaties; resource can be moved to another location without substantial loss of cultural value or replaced by a similar resource; resource is of a type that is common in the surrounding region; resource has cultural value to local stakeholders but limited value to national or international stakeholders; resource has limited scientific value or similar information can be obtained at numerous other resources; and/or resource meets IFC PS 8 criteria for replicable cultural heritage
Medium	Resource is specifically or generically protected by local or national laws but laws allow for mitigated impacts; resources eligible for inclusion on the NRHB or NRAS; resource can be moved or replaced, or data and artefacts recovered in consultation with stakeholders; resource has considerable cultural value for local and/or national stakeholders; resource has substantial scientific value but similar information can be obtained at a limited number of other resources; and/or resource meets IFC PS 8 criteria for non-replicable cultural heritage
High	Resource is protected by local, national, and international laws or treaties; resources listed on the NRHB or NRAS; resource cannot be moved or replaced without major loss of cultural value; legal status specifically prohibits direct impacts or encroachment on resource and/or protection zone; resource has substantial value to local, national, and international stakeholders; and/or resource has exceptional scientific value and similar resource types are rare or non-existent; and/or resource meets IFC PS 8 criteria for critical cultural heritage

IFC = International Finance corporation; NRAS = National Register of Archaeological Sites; NRHB = National Register of Historic Buildings; PS = Performance Standard

Impacts to cultural heritage resources can be divided into two broad categories: direct and indirect. Direct impacts consist of physical disturbance or damage to a resource that alters, either positively or negatively, the resource's scientific or cultural value. Indirect impacts are the result of changes to a resource's environment or natural setting that alter its cultural value or restricting or limiting stakeholder access to a resource. Direct and indirect impacts can occur during the construction, drilling, testing, and decommissioning activities of Project. Based on the proposed Project activities outlined in the Project Description, Table 5-38 provides a summary of the potential sources of direct and indirect Project impacts to cultural heritage resources.

Table 5-38: Criteria for Determining Cultural Heritage Resource Sensitivity

Impact Type	Project Activities
Direct	• Ground works such as vegetation clearance, grading, excavation, and well drilling, has the potential to damage, disturb, or remove known or previously undiscovered cultural heritage resources, particularly archaeological sites • The use of heavy machinery during construction; increased vehicular traffic along access roads; and well drilling could generate localized vibrations sufficient to damage cultural heritage resources • The accumulation of dust and pollutants due to vehicular traffic on cultural heritage resources could impact their cultural value; The accumulation of other pollutants could physically damage resources from chemical reactions between pollutant and resource material • Project staff or subcontractor looting and/or vandalism • Accidental events such as traffic accidents
Indirect	• Impacts to the setting of cultural heritage resources could include changes to the views to and from a resource (view shed impacts); increased noise levels at a resource; and/or the production of strong or offensive odors at or near a resource • Altering or restricting stakeholder access to resources due to construction during road upgrades and increased vehicular traffic during construction and well drilling

The significance of potential impacts to cultural heritage resources is assessed through a combination of the sensitivity of the resource and the magnitude of potential impacts. Table 5-39 provides the criteria used to assess the magnitude of potential impacts to cultural heritage resources.

Table 5-39: Criteria for Assessing Impact Magnitude

Magnitude	Characteristics
Negligible	No discernable change in the physical condition, setting, or accessibility of the resource
Small	Small part of the resource is lost or damaged, resulting in a loss of scientific value; setting undergoes temporary or permanent change that has limited effect on the resource's perceived value to stakeholders; stakeholder/public or scientific access to the resource is temporarily impeded; and/or historic building suffers minor, reparable, structural damage
Medium	A significant portion of the resource is lost or damaged, resulting in a loss of scientific or cultural value; setting undergoes permanent change that diminishes the resource's perceived value to stakeholders; resource becomes inaccessible for the life of the Project to stakeholders including traditional users or researchers; and/or historic building suffers major structural damage that is not reparable
Large	The entire resource is damaged or lost, resulting in a nearly complete or complete loss of scientific or cultural value; setting is sufficiently impacted to cause resource to lose nearly all or all cultural value or functionality; resource becomes permanently inaccessible to stakeholders including traditional users or researchers; and/or historic building suffers major structural failure

5.6.2 *Cultural Heritage Impact Discussion*

Based on the cultural heritage sensitivity criteria, types of potential Project impacts, and the criteria for assessing impact magnitude provided above, Table 5-40 provides a summary of the sensitivity of the known cultural heritage resources identified during the baseline study and the significance of potential unmitigated Project impacts to known and undiscovered cultural heritage resources.

Table 5-40: Impacts to Cultural Heritage Receptors

Receptor	Sensitivity	Impacts	Magnitude	Unmitigated Impact Significance
Byera Tunnel	**High**	**Direct:** Potential for damage due to traffic accidents during drill rig and construction equipment transportation through tunnel.	**Medium**	**Major**
		Indirect: The resource is part of the modern road infrastructure with traffic passes through the tunnel on a daily basis. The minor increase in traffic due to Project activities would have negligible impacts on the setting of the resource.	**Negligible**	**Negligible**
Black Point Historic Park	**High**	**Indirect:** Project activities would result in a small, temporary increase in vehicle traffic past the entrance to the park, resulting in negligible impacts on resource setting and stakeholder access.	**Negligible**	**Negligible**
Georgetown Anglican Church	**Medium**	**Direct:** Project activities would result in a small, temporary increase in vehicle traffic, which would result in small increases in vibrations, pollution, and dust along the transportation route. This increase would have negligible impacts on resources.	**Negligible**	**Negligible**
		Indirect: Project activities would result in a small, temporary increase in vehicle traffic past the church, resulting in negligible impacts on resource setting and stakeholder access.	**Negligible**	**Negligible**
Georgetown Methodist Church	**Medium**	**Direct:** Project activities would result in a small, temporary increase in vehicle traffic, which would result in small increases in vibrations, pollution, and dust along the transportation route. This increase would have negligible impacts on resources.	**Negligible**	**Negligible**
		Indirect: Project activities would result in a small, temporary increase in vehicle traffic past the entrance to the church, resulting in negligible impacts on resource setting and stakeholder access.	**Negligible**	**Negligible**
Mount Greenan Anglican Church	**Medium**	**Direct:** Project activities would result in a small, temporary increase in vehicle traffic, which would result in small increases in vibrations, pollution, and dust along the transportation route. This increase would have negligible impacts on resources.	**Negligible**	**Negligible**
		Indirect: Project activities would result in a small, temporary increase in vehicle traffic past the entrance to the church, resulting in negligible impacts on resource setting and stakeholder access.	**Negligible**	**Negligible**
Mount Greenan House	**Medium**	**Direct:** Project activities would result in a small, temporary increase in vehicle traffic, which would result in small increases in vibrations, pollution, and dust along the transportation route. This increase would have negligible impacts on resources.	**Negligible**	**Negligible**
		Indirect: Project activities would result in a small, temporary increase in vehicle traffic past the entrance to the house, resulting in negligible impacts on resource setting. The house is a private residence, not a tourist site. Increased traffic would have negligible effect on the homeowners access to the house.	**Negligible**	**Negligible**
Orange Hill Aqueduct and Sugar Mill Ruin	**Medium**	**Direct:** Project activities would result in a small, temporary increase in vehicle traffic, which would result in small increases in vibrations, pollution, and dust along the transportation route. This increase would have negligible impacts on resources as it is currently subject to similar impacts from daily traffic. Potential damage caused by traffic accidents during movement of drill rig and equipment through the aqueduct.	**Medium**	**Moderate**

Receptor	Sensitivity	Impacts	Magnitude	Unmitigated Impact Significance
		Indirect: Traffic passes through the aqueduct arches on a daily basis. Project activities would result in a small, temporary increase in vehicle traffic through the aqueduct, resulting in negligible impacts on resource setting and stakeholder access.	**Negligible**	**Negligible**
North Union Sugar Mill Ruin	**Medium**	**Indirect:** Project activities would result in a small, temporary increase in vehicle traffic past the sugar mill ruin, resulting in negligible impacts on resource setting and stakeholder access.	**Negligible**	**Negligible**
Rabbacca Estate House	**Medium**	**Indirect:** Project activities would result in a small, temporary increase in vehicle traffic past the estate house. However, due to the distance between the house and the road, increased traffic would not impact the resource setting. However the house is currently abandoned and fenced off which prevents potential stakeholders form accessing the site.	**Negligible**	**Negligible**
Biabou Community Cemetery	**Medium**	**Indirect:** Project activities would result in a small, temporary increase in vehicle traffic past the cemetery, resulting in negligible impacts on resource setting and stakeholder access.	**Negligible**	**Negligible**
Bridgetown Anglican Church	**Medium**	**Indirect:** Project activities would result in a small, temporary increase in vehicle traffic past the church, resulting in negligible impacts on resource setting and stakeholder access.	**Negligible**	**Negligible**
Black Point Sugar Mill Ruin	**Low**	**Direct:** Project activities would result in a small, temporary increase in vehicle traffic, which would result in small increases in vibrations, pollution, and dust along the transportation route. This increase would have negligible impacts on resources as it is currently subject to similar impacts from daily traffic.	**Negligible**	**Negligible**
		Indirect: Project activities would result in a small, temporary increase in vehicle traffic past the church, resulting in negligible impacts on resource setting and stakeholder access.	**Negligible**	**Negligible**
Dandrade 2	**Low**	**Direct:** The archaeological site is located along a road that would be widened by the Project. Ground disturbing activities associated with road construction could result in direct physical disturbance of the site. The exact location and size of the site could not be determined in the field and as a result, the extent of potential direct impacts could not be determined but are anticipated to be small to medium.	**Small-Medium**	**Negligible-Minor**
Orange Hill 1	**Low**	**Direct:** The archaeological site is located along a road that would be widened by the Project. Ground disturbing activities associated with road construction could result in direct physical disturbance of the site. The exact location and size of the site could not be determined in the field and as a result, the extent of potential direct impacts could not be determined but are anticipated to be small to medium.	**Small-Medium**	**Negligible-Minor**
Orange Hill 2	**Low**	**Direct:** The archaeological site is located along a road that would be widened by the Project. Ground disturbing activities associated with road construction could result in direct physical disturbance of the site. The exact location and size of the site could not be determined in the field and as a result, the extent of potential direct impacts could not be determined but are anticipated to be small to medium.	**Small-Medium**	**Negligible-Minor**

Receptor	Sensitivity	Impacts	Magnitude	Unmitigated Impact Significance
Lot 14	**Low**	**Direct:** The location of the Lot 14 site could not be determined in the field. The location of the site based on the coordinates provided by Dr. Callaghan does not match the original description of the site. Based on the original site description, the site is likely located along an access road that would be widened by the project. Ground disturbing activities associated with road construction could result in direct physical disturbance of the site. The exact location and size of the site could not be determined in the field and as a result, the extent of potential direct impacts could not be determined but are anticipated to be small to medium.	**Small-Medium**	**Negligible-Minor**
Undiscovered Archaeological Sites	**Low-High**	**Direct:** **T**he presence of a number of archaeological sites near the well pads, re-injection well sites, and roads suggests these Project components are located in an area where additional archaeological resources are likely present. Based on individual site characteristics undiscovered sites, if present, could be low, medium, or high sensitivity resources. Depending on the extent of any direct physical disturbance caused by Project construction activities the magnitude of Project impacts could range from negligible to large, resulting in impacts of negligible through major significance.	**Small-Large**	**Negligible-Major**

The majority of potential Project impacts to cultural heritage resources are direct and indirect impacts caused by increased vehicular traffic along the Windward Highway. These impacts would occur during mobilization and demobilization of equipment, materials, and staff to Project areas. The Windward Highway is the only available route for traffic traveling north to south on the windward side of the island. As a result, all of the resources along the route are subject to daily, relatively *Minor* direct and indirect impacts. The relatively small and temporary increase in traffic along the road during the mobilization and demobilization of equipment, materials, and staff to the Project area would not result in additional, significant adverse impacts to these resources.

Two of the built heritage resources along the Windward Highway could be subject to impacts from unanticipated or accidental events: the Orange Hill Aqueduct and the Byera Tunnel. The Byera Tunnel is a *High* sensitivity resource listed on the National Register of Historic Buildings (NRHB) while the Orange Hill Aqueduct is a *Medium* sensitivity resource due to its stated eligibility for listing on the NRHB. All Project traffic from Kingstown Port to the W1 well pad sites would have to pass through/under the Byere Tunnel, while traffic to W3 would also pass through the Orange Hill Aqueduct. Traffic accidents such as vehicles striking the Byera Tunnel due to insufficient vertical clearance, hitting the Orange Hill Aqueduct piers while turning onto the W 3 feeder road; or vehicle crashes could result in significant impacts to these resources.

There are no known sites within the Project footprint but a relatively high potential for undiscovered sites given the number of other known sites in the area. Ground works performed during well and injection pad construction and feeder road widening would likely result in direct impacts to four known prehistoric archaeological sites and could impact additional undiscovered sites. The Dandrade 2, Orange Hill 1, Orange Hill 2, and Lot 14 archaeological sites are located along the W 1 and W 3 feeder roads that would be widened by the Project. The available data indicates the sites are located along these roads, however the exact location and size of these sites is currently unknown. Ground disturbing activities during road widening could disturb and/or remove portions of these sites if they extend into the construction corridor. In addition to these known sites, the presence of a multiple sites in the study area suggests there is significant potential for additional undiscovered sites to be present. Any sites located wholly or partially within the footprint of Project components would also be subject to direct impacts.

To mitigate the abovementioned impacts, SVGCL and the Driller Contractor would implement a Cultural Heritage Management Plan as well as the Chance Finds Procedure (see Chapter 6.0, *Environmental and Social Management Plan*).

5.7 CUMULATIVE IMPACTS ASSESSMENT

This chapter focuses on potential cumulative impacts from the Project. Cumulative impacts are defined as the successive, incremental, and/or combined effects of a Project or activity, accumulated with other Projects or activities. Given that the Project is complying with the IFC PSs, potential cumulative impacts are evaluated pursuant to IFC's Cumulative Impact Assessment (CIA) guidance - *Good Practice Handbook - Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets* (IFC 2013).

A CIA focuses on environmental and social components rated as "critical" by the affected communities and the scientific community (Valued Environmental and Social Components [VECs]), which are cumulatively impacted by the Project, other projects, and sources of external pressure (IFC 2013). The development of a CIA requires the identification of VECs on the basis of the AoI of the Project; other existing, planned, and future projects; sources of external social and environmental pressure; and the results of consultation with stakeholders.

For this Phase I ESIA, a rapid CIA (RCIA) was conducted following the approach summarized and illustrated below in alignment with the IFC's Good Practice Handbook (see Figure 5-12). First, VECs are identified and their baseline conditions in the AoI are considered. Next, other projects and external pressures are identified that could influence the VECs in the future. The RCIA then identifies and assesses the future status of the VEC considering other projects, without considering the development of the Project. Finally, the difference between the future condition and that same future condition adding the Project is evaluated.

This RCIA was based on information provided by SVGCL, baseline information generated in the ESIA, information available in the public domain, and information gathered during the consultation process.

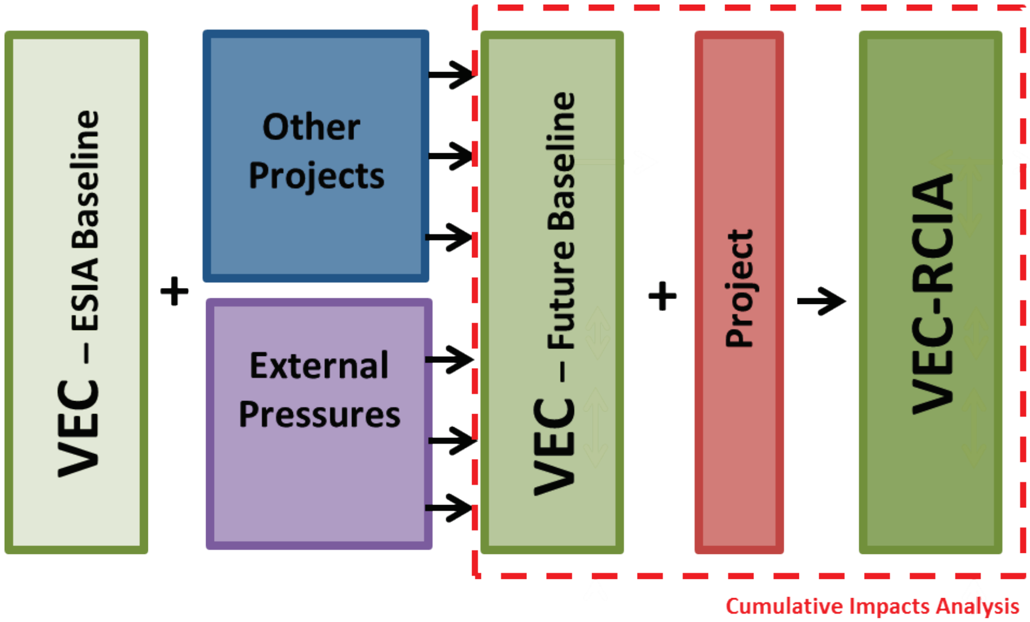


Figure 5-12: Rapid Cumulative Impact Analysis Scheme

5.7.1 VECs

The identification of VECs was based on social and environmental receptors identified in the assessment of impacts of the ESIA, other known activities in the project area, supplemented with information obtained during the baseline survey, and the consultation process of this ESIA through interviews and meetings with various stakeholders.

This ESIA concluded that most of the resources affected by the Project (e.g., soils, air quality, noise, most biodiversity, social, and health resources) would incur *Minor* or *Negligible* impacts that were very localized in extent and duration, considering the proposed Project only involves short term exploratory drilling. Taking into consideration the impacts of the Project and the location and nature of other projects and external pressures, the identified VECs for this RCIA are:

- Project-affected people; and
- Terrestrial biodiversity, including rare and endemic species.

Chapters 4 and 5 of this ESIA describe the baseline condition and impacts of the Phase I Project on these VECs, respectively. In summary, the Project area is rural in nature, characterized by small villages, agricultural plots, and the La Soufrière Volcano. Very few people live in the Project area and the primary human uses of the area are farming and tourism. As such, impacts to people from Phase I activities are limited to physical resettlement of at most a few families, the economic displacement of the small scale farmers who farm lands in the Project Area.

The pad sites consist of active or fallow agriculture and regenerating vegetation but the broader landscape is dominated by the natural habitats of the La Soufrière Volcano including several types of high quality secondary forest, particularly within the La Soufrière National Park and Mount Pleasant Forest Reserves, which lie immediately east and southwest of the Project area, respectively. The biodiversity of this broader landscape is diverse and plentiful and, as is common on small islands, the island has many (49) rare and/or endemic or restricted range species. Twenty-nine of these species occur or are expected to occur in the Project area of influence, although the well pad and reinjection pad sites themselves do not support a concentration or subpopulation of any of these species. Two of the rare and endemic species known to occur in the immediate Project area (pad sites) are listed on the IUCN Red List: the St. Vincent Parrot (listed as vulnerable) and the St. Vincent Whistling Frog (listed as endangered). The Project is likely to impact individuals of these and other endemic/restricted range species as well as other more common biodiversity resources that occur in the Project AoI a result of habitat loss and disturbance and increased human activity (e.g., noise, light). In addition, emissions of air pollutants, particularly H_2S, may affect flora and fauna in the immediate vicinity of the well pads to a small degree.

5.7.2 *Other Projects and External Pressures*

We conducted a review of available information on past, existing, or future projects and external pressures located within the AoI. The Project Area is a rural area characterized by small villages, agricultural plots, and the La Soufrière Volcano. Past and existing uses are primarily agricultural and small scale residential in nature. At this point, only one other project has been identified within the AoI:

- St. Vincent Geothermal Project Phase II – this project would be the continuation of the current proposed project, assuming that the exploratory drilling is successful. Phase II would involve construction of a power plant at the selected well pad site and an electric transmission line system that would bring the electricity generated by the project to the existing St. Vincent grid.

The primary external pressure affecting VECs in the AoI is forest loss due to natural hazards (e.g., landslides, volcanic eruptions) and conversion for agriculture.

5.7.3 *Potential Cumulative Impacts*

As stated above, cumulative impacts include the successive, incremental, and/or combined effects of a Project or activity that accumulate with other Projects or activities (IFC 2013). The potentially cumulative impacts created by Phase I and Phase II activities are:

- ongoing displacement of human receptors (i.e., farmers) at and in the immediate vicinity of the Phase II facilities, including but not limited to the transmission line; and
- ongoing and new habitat loss and degradation at and in the immediate vicinity of the Phase II facilities, including but not limited to the transmission line.

As part of the Phase II ESIA, a full CIA should be carried out to fully assess the magnitude and significance of these and potentially other cumulative impacts related to the Phase II Project.

5.7.3.1 *Ongoing Displacement of Farming Activities*

Ongoing occupation of land for the Phase II activities would result in the continued displacement of farmers from the Project site and immediate surrounding area. Additionally, new physical and economic displacement may be required as a result of the transmission line, the extent of which cannot be determined until a route is determined.

5.7.3.2 *Habitat Degradation and Loss*

The Phase I activities would result in habitat degradation (from human activity, noise, and air emissions) and direct habitat loss at and in the immediate vicinity of the pad sites. This impact would be temporary in areas not affected by the Phase II activities (areas not used for Phase II activities would be restored to pre-Project conditions), but long term (successive) for the area around the selected site for Phase II.

Ongoing noise and human activity would continue to displace wildlife species that are sensitive to noise and human disturbance. Some species would habituate to the ongoing noise and human activity in Phase II, as the noise level is expected to be lower and more predictable/steady than in Phase I and the level of human activity is expected to decrease during the operational stage of Phase II. The primary air emission of concern related to the Project for biological receptors is H_2S and this pollutant would be emitted during Phase I drilling and blow testing activities and during Phase II from operation of the power plant. Emissions of H_2S during Phase I and II activities are expected to be low and limited to a small area around the well pad and injection pad sites and the power plant. Nevertheless, flora and fauna occurring within the exposure zone could be affected by exposure to this pollutant. The successive nature of the Phase I and II activities could create an ongoing exposure which could be more damaging than the short-term exposure created by the Phase I activities alone, particularly in plants and sessile species that are stationary or move only short distances.

The Phase II project involves construction and operation of the transmission line, which would result in cumulative impacts related to habitat loss and fragmentation, wildlife disturbance and displacement, and wildlife injury or mortality.

Habitat loss would be inevitable within the transmission line right-of-way and this would fragment intact forest habitats and degrade wildlife habitat conditions within and adjacent to the right-of-way. The degree of fragmentation and habitat degradation would depend on the alignment of the right-of-way and whether it traverses intact or modified habitats.

The transmission line could result in bird collisions and electrocutions, leading to injury or mortality of birds that fly into the transmission lines or their supporting structures, or perch or attempt to nest on or near grounded or electrified parts (Manville 2005). Several factors influence the likelihood of bird-transmission line collisions including the line's proximity to habitat, the line's physical structure, the bird's flying ability, and the line's height in relation to the surrounding tree canopy (i.e., if the transmission line height is close to that of the tree canopy, the frequency of bird strikes increases because many birds fly at this altitude for some distance after taking off or before landing). Several studies cite the highest number of avian-powerline interactions where transmission lines cross flyways, separate feeding areas from nesting and roosting areas, or are located near other areas used intensively by birds (Scott *et al*. 1972; Malcolm 1982; McNeil *et al*. 1985; Brown *et al*. 1987; Faanes 1987; Morkill and Anderson 1991). Further, the introduction of new transmission lines into an area where there are none or few leads to a higher bird strike and electrocution rate than in areas where transmission lines are a regular landscape feature because many birds learn the dangers of transmission lines and develop avoidance behaviors to minimize the potential for strikes and electrocutions (Sovacool 2009).

Generally, collision and electrocution events occur to birds that are not highly maneuverable, heavy birds, and birds that fly in flocks (Manville 2005) and all of these risk factors apply to one of the rare and endemic species that occurs in the Project area – the St. Vincent parrot. Parrots as a group are generally recognized as being at risk for collision and electrocution from power lines because of their large size, flight pattern and height, and flocking behavior (Derouaux 2012).

The Project's transmission line design (e.g., its height and pole type) and alignment have not been established at this time, although the preliminary designs being considered involve two transmission lines to provide system redundancy: one running along the site access road and then south along the Windward Highway and another running inland which, depending on its location, could traverse the St. Vincent Parrot Reserve. Because the Reserve is the parrot's breeding stronghold, significant, population-level impacts on the species could occur if the transmission line is constructed through the Reserve or other primary breeding habitat for the species. The inland transmission line would be the first transmission line introduced into the area and given the parrot's inherent risk due to its body size and flight behavior and the location of the line within or in proximity to high quality parrot habitat, the risk of collision and electrocution with the inland transmission line would be moderate to high. The other transmission line that parallels existing roads poses a much lower risk of collision and electrocution because the line would not traverse key habitats for the species.

Designing the inland transmission line right-of-way to avoid the St. Vincent Parrot Reserve and minimize impacts to intact forest outside the Reserve and the identification and subsequent avoidance of occupied or preferred habitats of rare and endemic species would reduce the magnitude of the impact of the transmission line on biodiversity.

ERM recommends that SVGCL and/or VINLEC (the SVG electric utility) develop a Transmission Line Feasibility Study that considers route alternatives and begin to collect field data that would support a robust evaluation of route alternatives.

Page intentionally left blank.

6.0 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

6.1 INTRODUCTION

This Chapter describes the proposed approach that St. Vincent Geothermal Company Limited (SVGCL) as well as the Drilling Contractor would follow to manage, mitigate, and monitor the potential impacts of the St. Vincent Geothermal Project Phase I Exploration (the Project).

This Environmental and Social Impact Assessment (ESIA) has identified a range of potential environmental, socioeconomic, and cultural impacts related to the Phase I activities (i.e., access improvements and transportation; drill site preparation; drill rig installation and drilling; exploratory blow testing; decommissioning; see Chapter 5.0, *Impact Assessment*). As part of the environmental and social management requirements established by the *Draft Environmental Impact Assessment Regulations* (2009) of St. Vincent and the Grenadines (SVG), and according to industry good practice, an Environmental and Social Management Plan (ESMP) needs to be developed for the Project.

This ESMP includes the Project commitments and mitigation measures as identified in Chapter 5.0, *Impact Assessment*. This ESMP provides the framework of these mitigation measures and describes the specific management plans to be implemented to avoid, minimize, compensate, and/or offset negative impacts and/or enhance positive impacts associated with the Project.

This ESMP is an evolving document that will be refined and adjusted throughout the Project. Revisions may be required during the ESIA approval process and as a result of specific conditions required by the Government of SVG.

6.2 ORGANIZATIONAL CAPACITY AND POLICIES

The key parties and their primary roles in implementing this ESMP are:

- **SVGCL**, as the Project Proponent, is responsible for overall Project monitoring, ensuring compliance with environmental and social policies and obligations in the ESMP, and ensuring that its commitments, as well as any other lender or SVG requirements, "flow down" to the Drilling Contractor as contractual requirements; and
- **Drilling Contractor** is responsible for complying with ESMP, lender, and SVG requirements set out by SVGCL.

The staff and position responsibilities required to implement the Project ESMP are listed in Table 6-1. SVGCL will be responsible for overseeing the implementation of the Environmental, Social, and Health and safety (ESHS) ESIA and ESMP commitments and implementing all social aspects (i.e., Stakeholder Engagement Plan, Resettlement Action Plan, social management plans). As indicated by the *Request for Proposal for Supply of Drilling Services* (RG and EC 2015), the Drilling Contractor will be required to meet all SVGCL's Environmental, Health, and Safety (EHS) requirements and follow good industry practice (e.g., *ISO 9001 Quality Standards, ISO 14001 Environmental Standards*, and *OHSAS 18001 Ocuppational Health and Safety Standards*).

Table 6-1: Project Environmental and Social Roles and Responsibilities

Position	Responsibility
SVGCL	
ESHS Director	• Responsible for the implementation of the ESMP. • Manages the activities of the ESHS team.
Environmental and Social Manager	• Oversees and coordinates all activities pertaining to the ESMP. • Responsible for implementing the Stakeholder Engagement Plan (SEP) and Resettlement Action Plan (RAP). • Reports monitoring findings as stipulated in the ESMP.
Community Liaison Officer	• Leads stakeholder engagement associated with RAP. • Ensures effective communication with all stakeholders. • Reports monitoring findings to stakeholders. • Implements the Grievance Mechanism.
Drilling Contractor	
Site Manager	• Responsible for the implementation of the ESMP.
EHS Manager	• Implements mitigation and management measures in the field per the ESMP. • Monitors and reports on performance and cooperates with audits and reviews. • Inspects the site and surrounding areas on a daily basis with regard to compliance with the ESMP and keeps records of these inspections. • Reports any incidents of non-compliance with the ESMP.
Emergency Response Coordinator	• Responsible for overall organization, strategy, and implementation of the emergency response. • Coordinate logistical efforts to implement an emergency response. • Communicate all events to the EHS Manager and Site Manager. • Coordinates and expedites post emergency operations.

EHS = Environmental, Health, and Safety; ESHS = Environmental, Social, and Health and Safety; ESMP = Environmental and Social Management Plan

The Project will comply with all applicable national laws, regulations, and rules, including the SVG *Occupational Safety and Health Act 2012*, as well as international standards – mainly International Finance Corporation (IFC) Performance Standards (PSs) and IFC General EHS Guidelines and EHS Guidelines for Geothermal Power Generation.

SVGCL will develop ESHS policies specific to the Project in compliance with IFC PSs and EHS Guidelines. As Emera Caribbean Incorporated and Reykjavik Geothermal have existing corporate policies, these could be used as a basis for the SVGCL policies. SVGCL will ensure that all policies are reviewed periodically, communicated, made accessible to all personnel (whether directly employed or contracted), and are publicly available upon request.

6.3 ESMP GUIDING PRINCIPLES

6.3.1 Plan, Do, Check, Review

Industry good practice follows the general principles of the "Plan, Do, Check, Review" cycle as described below, and outlined in Figure 6-1.

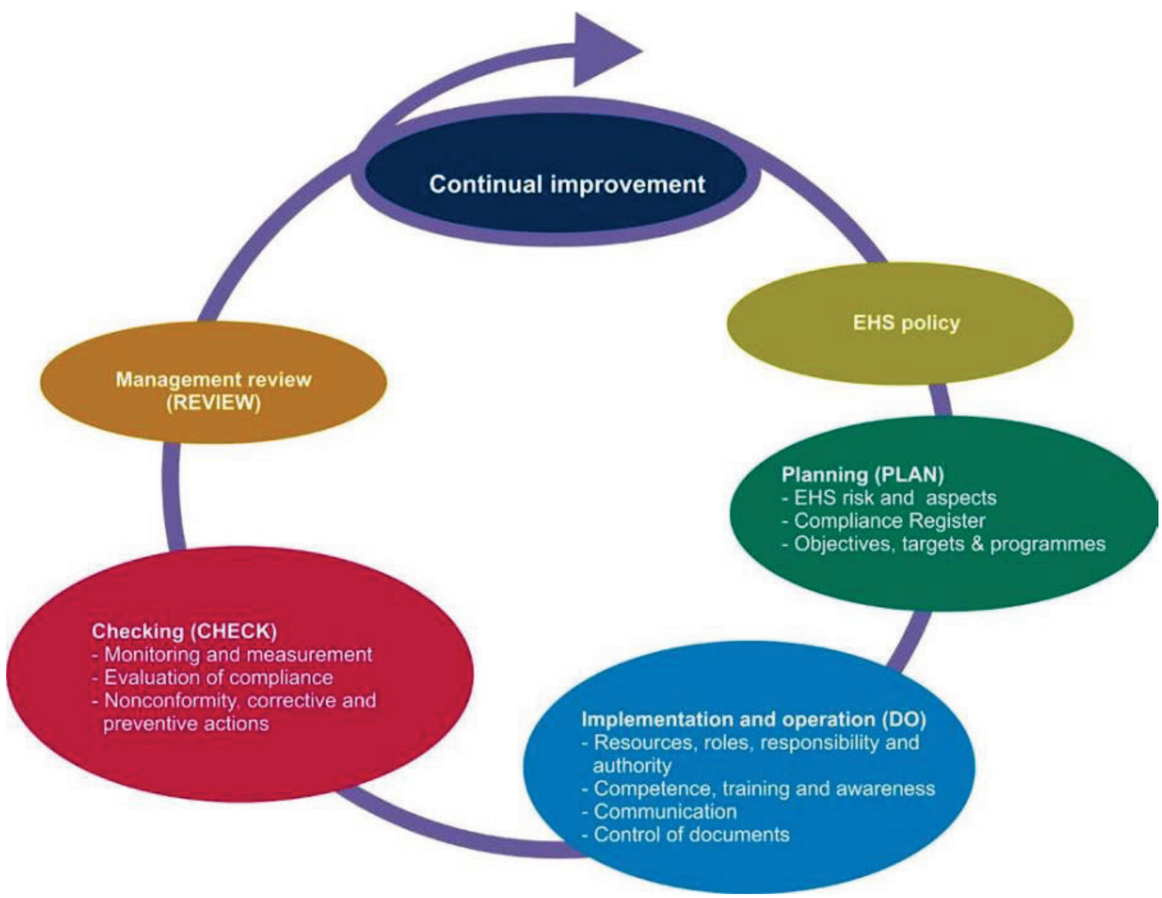


Figure 6-1: Plan, Do, Check, Review Cycle

6.3.1.1 *Plan*

- Define policies and objectives for environmental and social performance.
- Identify environmental and social impacts and risks of the operations.
- Develop mitigations and operational controls to address impacts and risks.
- Develop a management plan to achieve these objectives.

6.3.1.2 *Do*

- Implement a management plan.
- Implement mitigation and operational controls.

6.3.1.3 *Check*

- Monitor performance against policies and objectives.
- Check that mitigation and operational controls are effective.

6.3.1.4 *Review*

- Make corrections to plans, mitigation, or controls in response to performance monitoring or out of control events.

6.3.2 *Mechanism for Auditing, Adjustments, and Reporting*

Auditing and adjustment is an essential part of a successful ESMP. Auditing systems include inspections and monitoring to confirm proper implementation of the ESMP, as well as effectiveness of mitigation measures. Corrective actions include response to out-of-control situations, non-compliances, and non-conformances. Actions also include those intended to improve performance.

Representatives of the ESHS team will conduct environmental and social responsibility inspections to ensure that all personnel (employees or contractors) are fulfilling their obligations. The results of the inspections will be reported on a weekly basis or as specified in the ESMP.

Monitoring will be conducted to ensure compliance with ESIA commitments and to evaluate the effectiveness of operational controls and other measures intended to mitigate potential impacts. The Project monitoring plan is presented in Section 6.4, *Project Plans*. The monitoring plan describes what metrics will be measured and the frequency, and will serve to confirm that the Project is meeting its obligations with respect to environmental management and work practices.

Identifying potential impacts, hazards, and risks is an important part of the environmental and social management and monitoring approach. Equally important is the investigation and root cause analysis of accidents and "near misses" so that valuable lessons and information can be used to prevent similar or more serious occurrences in the future. SVGCL will investigate cause and identify corrective actions in response to accidents or environmental or social non-compliances. This will ensure coordinated action between SVGCL and the Drilling Contractor. Where corrective actions are deemed necessary, specific plans (with designated responsibility and timing) will be developed to achieve continuous improvement in performance.

SVGCL will keep relevant authorities informed of the Project performance with respect to environmental and social matters by way of written status reports and face-to-face meetings. SVGCL will provide appropriate documentation of ESHS-related activities to relevant authorities as required. The Drilling Contractor will also be required to provide EHS performance reporting as relevant based on the contractor's responsibilities. SVGCL will follow the *Stakeholder Engagement Plan* (The Geothermal Consortium 2015b) on how to deliver regular reporting to stakeholder groups regarding Project activities and results of environmental and social monitoring.

6.3.3 Training

All Project personnel will be qualified to the particular job that they are performing and undergo further training to meet the needs of the working environment, as required. All personnel, regardless of position, will be given specific job oriented EHS training prior to starting work and as necessary thereafter. All personnel will be trained on general awareness of environmental issues and specific procedures aimed at the avoidance of environmental damage as well as the Project's Worker Code of Conduct. New staff, contractors, and visitors will be given basic induction training and follow Project EHS procedures.

6.4 PROJECT PLANS

The Project ESMP, presented in Appendix E, will be implemented to prevent, minimize, and offset loss or damage from the proposed Project. The ESMP addresses the Project activities and issues identified in the ESIA, and set out management strategies in accordance with proposed performance criteria for specified acceptable levels of environmental and social performance. The plans identify:

- Potential impacts on environmental receptors and social values;
- Mitigation strategies;
- Performance monitoring;
- Key Performance Indicators; and
- Appropriate corrective actions should an undesirable impact or unforeseen level of impact occur.

SVGCL is committed to providing resources essential to the implementation and control of the ESMP.

This ESMP is comprised of the following plans:

- Drill Mud and Cuttings Management;
- Noise Management;
- Soil and Erosion Control;
- Water Resources Management;
- Spill Prevention Control and Countermeasures;
- Decommissioning and Restoration;
- Biodiversity;
- Socioeconomic and Health Management;
- Cultural Heritage Resources;
- Transportation and Traffic Management; and
- Environmental and Social Monitoring Plan.

In addition, SVGCL will develop and ensure implementation of the following plans:

- Emergency Response Plan – defines the procedures to be implemented in a forecasted event (e.g., hurricane or tropical storm) or an unanticipated event (e.g., earthquake, volcano eruptions).
- Journey Management Plan - defines the process all Project staff and contractors will follow for planning and undertaking road transport journeys to ensure compliance with community and worker health and safety requirements; and
- Local Employment and Supplier Development Plan - outlines the local employment strategies and opportunities for workers and suppliers, and the process by which locals can participate in the bidding and application process.

7.0 STAKEHOLDER CONSULTATION AND DISCLOSURE

St. Vincent Geothermal Company Limited (SVGCL) has identified a variety of internal and external stakeholders for the Project, including:

- Project-Affected Persons and Project-Affected Communities (described in Section 4.3, *Socioeconomic and Health Baseline*);
- Affected local population (described in Section 4.3, *Socioeconomic and Health Baseline*);
- Regulatory and executive governmental bodies at a national level (described in Section 2.1, *Legal and Administrative Framework*);
- Non-governmental organizations (NGOs) and interest groups; and
- Mass media.

SVGCL currently maintains regular stakeholder engagement with these groups; engagement completed to-date is summarized in the list below. Further details can be found in the Project's Resettlement Action Plan (RAP) (The Geothermal Consortium 2015a) and Stakeholder Engagement Plan (SEP) (The Geothermal Consortium 2015b).

- SVGCL held several stakeholder engagement events in 2013 through 2015, including community ("townhall") meetings and a presentation to the Government of St. Vincent and the Grenadines (SVG) Cabinet in February 2015.
- As part of the baseline study conducted early 2014, before the Project Area and exploratory drill sites had been located, SVGCL developed a questionnaire to improve understanding of the socioeconomic conditions of the population in the immediate Area of Influence. The purpose was to collect information about the Project Area and gather opinions and expectations.
- During the Project's screening phase, SVGCL led stakeholder engagement activities in July 2015 where they disclosed Project information and documented issues and concerns.
- During the Project's scoping phase, 12 separate consultation and disclosure meetings occurred with certain categories of stakeholders (i.e., Affected Communities, Government of SVG, ministries and departments, and NGOs) in October 2015. SVGCL reported these in the Project's SEP report.
- SVGCL conducted various individual consultations in 2015 with the Project-Affected People for preparation of the RAP. SVGCL reported these in the Project's RAP report. The consultations include individual informal meetings with the Project staff and landowners in March, May, and November 2015. Resettlement-related consultation continues.

- Informal consultations by SVGCL with Government of SVG stakeholders continued throughout 2015.
- During the Project's Environmental and Social Impact Assessment (ESIA) baseline data collection in February 2016, ERM conducted a series of informal interviews and consultations with the Project-Affected Persons, Project-Affected Communities, and Project-Affected local population to discuss the ESIA process, initial findings, and Project-led plans for the future Public Consultation and Disclosure engagement scheduled for April 2016.

These stakeholder engagement activities have allowed SVGCL to understand the issues, concerns, and comments of stakeholders regarding Project activities. Some of the most common themes are captured in the RAP and SEP, and summarized below:

- Economics - number of jobs to be created by the Project; Project impact on retail price of electricity;
- Environmental - effects from drilling on the La Soufrière Volcano or any seismic effects (e.g. earthquakes); water sources and availability;
- Biodiversity - impacts to endemic species in the Project Area (i.e. St. Vincent Parrot);
- Social – road improvements; land acquisition needs and reduced access; improved business opportunities; tourism effects; and
- Health - increased traffic, noise, light and air quality as a result of the Project; possibility of increase in asthma rates.

A Public Disclosure Meeting is planned for late-April 2016 to meet the requirements of the Government of SVG and the International Finance Corporation (IFC) Performance Standards. The primary purpose of the Public Disclosure Meeting will be to disclose the results of the ESIA and to present to stakeholders the recommended mitigation measures to minimize environmental and social impacts of the Project, in an inclusive and effective manner. Prior to the Meeting, in accordance with IFC guidelines, the draft ESIA, or at a minimum a non-technical summary, will be made available to the public. This early disclosure will allow the public to be informed prior to the Meeting and facilitate informed dialogue about the Project's potential positive and negative impacts.

A Grievance Mechanism has been developed as part of the SEP and is planned to be made available at the Public Disclosure Meeting.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

This chapter summarizes the conclusions of this Environmental and Social Impact Assessment (ESIA) relative to the St. Vincent Geothermal Project Phase I Exploration (the Project), and provides recommendations in the form of an Environmental and Social Action Plan (ESAP) to fill the remaining gaps relative to conformance with the International Finance Corporation (IFC) Performance Standards (PSs).

8.1.1 Purpose and Need

St. Vincent and the Grenadines (SVG) is largely dependent of imported fossil fuels to meet its electricity demand, resulting in relatively high per capita greenhouse gas emissions and a large portion of the gross domestic product spent on purchasing energy. Successful implementation of the St. Vincent Geothermal Project Phase II (Production) would increase the proportion of clean renewable energy in the national energy mix; lower and stabilize energy prices; reduce reliance on imported fossil fuels; reduce carbon emissions; and increase energy independence and sovereignty. The Project can also result in energy expansion and possible economic development. It aligns with the SVG *Energy Policy* (2009) and *Energy Action Plan* (2010).

8.1.2 Site Selection

St. Vincent Geothermal Company Limited (SVGCL) evaluated several locations before selecting the two proposed exploratory drill pad sites: W1 and W2. The sites need to be near the La Soufrière Volcano, which is the source of the geothermal heat resource. Based on resistivity surveys and access considerations, the windward side of the island was determined to be the most suitable location. Nine potential windward pad sites were considered for drilling, and the two preferred sites were identified taking into consideration land use, land acquisition, access, and topography. The two proposed sites, but especially Pad W1, present relatively few environmental and social impacts, and all identified risks can be readily mitigated.

8.1.3 Project Design

A Project Feasibility Study was prepared for the two proposed exploratory drill pad sites, W1 and W3, which indicated that these sites are feasible from an engineering perspective. However, additional design work is needed. For example, although the location of the exploratory drill pad sites have been precisely identified, the exact location of the water system and the injection pad have not yet been finalized for either site. Further, although the Rabacca River is the likely water source for both sites, how the water would be transported from the river to Pad W3 is not yet known. The ESAP identifies the additional design work required prior to the initiation of Project construction (see Section 8.2.1, Environmental and Social Action Plan).

8.1.4 *Conformance with International Standards*

Table 8-1 summarizes the Project's conformance with the IFC PSs (2012). The key potential impacts and recommended mitigation measures are discussed below.

- **Stakeholder Engagement** – Knowledge of the Project varies among Project-Affected Communities; some are very familiar with the Project, but others appear to know little. The SVGCL has developed a robust Stakeholder Engagement Plan (SEP), which needs to be made publically available and, most importantly, implemented. ERM recommends that SVGCL hire a local Community Liaison Officer (CLO) who can help keep the community informed about the Project and help address community concerns through implementation of the Project's Grievance Management. Implementation of these measures should adequately manage this potential risk.
- **Soil Erosion** – The Project could disturb steep slopes in a relatively wet climate, and therefore has the potential for significant soil erosion. ERM recommends that SVGCL develop and implement a Soil and Erosion Control Plan. Implementation of this plan should adequately manage this potential risk.
- **Water Resources** – SVGCL proposes to withdraw water from the Rabacca River to meet the Project's exploratory drilling water demands, which primarily involves mixing water with bentonite (a clay) to serve as a lubricant. For the initial stages of drilling, there should be sufficient water in the Rabacca River to meet the Project's estimated water needs (0.2 liters per second [L/s]) and still leave sufficient water to support aquatic life in the river. During the final stage of drilling, however, the Project's water demand increases to 40 L/s for approximately 20 days. ERM recommends that SVGCL schedule their construction to avoid the final stage of drilling coinciding with the end of the dry season (January to March) to adequately manage these risks, or identify an alternative water supply source in case of low flows.
- **Aquatic Biodiversity** – The proposed water withdrawals from the Rabacca River could result in the loss of some aquatic habitat depending on the time of year. Migratory shrimps and the Sirajo goby fish rely on increased freshwater inputs from the river as a cue to begin migrating upstream. Proposed water withdrawals would decrease the volume of freshwater, thereby reducing the strength of this migratory cue. These species also require a connected river system in order to reach upstream spawning habitat and for larvae to descend to the coast. Some of these species could be entrained at the Project water intake or be susceptible to unplanned hazardous material spills. ERM recommends that SVGCL try

to avoid/minimize large water withdrawals during the end of the dry season, minimize the water intake velocity to the extent possible, and install wedge wire screens on the water intake to minimize entrainment, implement spill control plans, and enforce a strict no freshwater fishing policy for Project workers. These measures should adequately manage these risks to aquatic biodiversity.

- **Terrestrial Biodiversity** – The Project has a small footprint and would only directly impact a small area of modified habitat (e.g., banana plantation). The Project would also not directly impact any protected areas, but would temporarily degrade habitat quality as a result of noise, light, and increased human activity within the nearby La Soufrière National Park and Mount Pleasant Forest Reserve. As is common on small islands, the island of St. Vincent has 49 endemic or restricted range species, 29 of which occur or are expected to occur in the Project area, although the Project area is not known to support a concentration of any of these species. Two of the species are listed on the International Union for the Conservation of Nature Red List of Endangered Species: the St. Vincent Parrot (listed as Vulnerable) and the St. Vincent Whistling Frog (listed as Endangered). The Project is likely to impact individuals of these endemic/restricted range species to some extent as part of the required land disturbance and increased human activity (e.g., noise, light). ERM recommends that SVGCL conduct pre-clearing surveys immediately prior to construction to flush wildlife from areas to be disturbed, relocate sessile or limited mobility species to undisturbed sites to the extent practicable, and enforce a strict no hunting policy for Project workers. ERM recommends that SVGCL avoid initiating construction during the St. Vincent Parrot (and other endemic bird species') breeding season (January to June) to avoid disturbing nesting birds, if operationally possible. Minimize noise from drilling and steam blow testing as described below. Implementation of these measures should adequately manage these risks
- **Waste Management** – The Project would generate drill muds, drill cuttings, domestic wastewater, and small quantities of other miscellaneous solid wastes. Neither the drill muds nor cuttings are hazardous, and would be stored in a lined mud pond where the muds would be reused as a drilling lubricant and the cuttings (mostly rock) would settle to the bottom of the pond. After drilling is completed, the mud pond would be properly closed. The Project would also generate geothermal liquids, which are typically composed of high concentrations of various dissolved minerals. SVGCL proposes to collect and inject these liquids back underground. A latrine with a septic system would be provided to handle worker domestic wastewater. Miscellaneous solid waste would be disposed of in accordance with SVG regulations.
- **Noise** – Drilling and blow testing could generate noise levels of up to 120 A-weighted decibels (dBA). This intensity of noise, combined with 24-

hour drilling, although temporary, results in exceedances of international nighttime noise standards (45 dBA) at distances of up to 500 meters for drilling. As drilling noise can vary by drill rig, ERM recommends that SVGCL monitor noise levels immediately upon the initiation of drilling and implement a Corrective Action Plan (e.g., additional noise mitigation or physical resettlement) if noise levels exceed standards. SVGCL would provide Personal Protective Equipment for its employees and ear protection for nearby farmers if needed. Implementation of these measures, and at the worst case limited additional physical resettlement, should adequately manage these risks.

- **Land Acquisition and Economic Displacement** – The Project design has not advanced sufficiently at this time to fully assess the Project's land acquisition, physical resettlement, and economic displacement requirements. The draft Resettlement Action Plan (RAP) is robust, but needs finalization for the identification of people subject to physical or economic displacement. Based on ERM's field review of the general locations for the Project components, physical resettlement would likely be limited to a couple families. There are, however, small scale farmers who farm lands in the Project area that may be economically displaced. Once the Project design is finalized (at least for Pad W1), SVGCL will finalize a compensation program and continue to implement the RAP. No land acquisition should occur at Pad W1 unless in accordance with the RAP. Implementing the RAP and negotiating with the Project-Affected People regarding compensation in accordance with the IFC PSs should adequately address these issues.
- **Worker Code of Conduct and Grievance Mechanism** – The Project would require up to 40 workers, about 70 percent (approximately 28 workers) would be foreign labor. These workers would most likely be housed in nearby communities and would work at the Project site for several months (more if drilling at Pad W3 is required). There is always the potential for conflict between foreign workers and local communities (e.g., prostitution, drugs, and spread of diseases such as HIV/AIDS). ERM recommends that SVGCL develop a Worker Code of Conduct to help manage these potential conflicts, with penalties (ultimately leading to termination of employment) for worker non-compliance. In addition, SVGCL should implement the Grievance Mechanism that provides a process to review and address any community complaints (e.g., worker conduct, noise, traffic). Implementation of these measures should adequately manage these risks.
- **Recreation and Tourism** – The preferred exploration drill pad, W1, is located along the feeder road to the Bamboo Range Hiking Base Station, where hikers ascend the La Soufrière Volcano, one of the most popular tourist attractions in SVG. The Project would affect these recreational users by increasing noise levels and changing the visual landscape as they pass Pad W1. These impacts are considered minor as the noise and visual

effects are quickly reduced to negligible levels as hikers leave the Base Station and ascend the volcano. In fact, a geothermal power development with appropriate information signage could function as a complementary attraction for tourists to the volcano.

- **Cultural Heritage** – The Project has the potential to affect the Byera Tunnel, the Orange Hill Aqueduct, and potentially other culturally important sites along the transport route of the drill rig and other equipment/materials to the pad sites. The SVGCL proposes to develop a Journey Management Plan that will help ensure measures are in place to protect these historic resources. There is also the potential that unanticipated discoveries may occur during construction, given the number of other archaeological sites known to occur in the Project area. ERM recommends that a Chance Finds Plan be adopted and implemented (see the Cultural Heritage Management Plan in Appendix E). Implementation of these plans should adequately manage these risks.

Table 8-1: Project Alignment with the IFC Performance Standards on Social and Environmental Sustainability

IFC Performance Standard	Triggered by Project	Project Issues	Recommended Actions[1]
PS 1 Social and Environmental Assessment and Management Systems	*Yes*	• Stakeholder Engagement • Grievance Mechanism • ESMS	• Finalize and implement a Stakeholder Engagement Plan (ESAP #1) • Hire a Community Liaison Officer to engage with local communities (ESAP #10) • Establish and implement a Grievance Mechanism (ESAP #2) • Develop and implement an ESMS (ESAP #4)
PS 2 Labor and Working Conditions	*Yes*	• Worker Code of Conduct • Occupational H&S	• Develop and implement a Worker Code of Conduct (ESAP #7) • Develop and Implement an Occupational H&S program for Project workers, including the provision of necessary PPE (see ESMP) and H_2S monitoring (ESAP #13).
PS 3 Pollution Prevention and Abatement	*Yes*	• Air Quality - H_2S emissions • Soils – erosion potential • Noise – noise generation • Water – water withdrawals • Water – accidental spills • Wastes – drill muds and cuttings • Natural Hazards	• Monitor H_2S emissions to protect both workers and nearby residents (see ESAP #13)) • Develop and implement a Soil Erosion and Sediment Control Plan (ESAP #6 and ESMP #3) • Implement Noise Management Plan (ESMP #2) • Monitor noise levels and implement corrective action plan if needed (ESAP #13 and ESMP #11) • Schedule Project to avoid large water withdrawals occurring during the dry season (January – March) (ESAP #11) • Implement a Spill Prevention and Control Plan (ESMP #5) • Implement the Drill Mud and Cuttings Management Plan (ESMP #1) and the Water Resources Management Plan to manage brine and geothermal liquids (ESMP #4) • Implement an Emergency Response Plan in the event of any natural disasters
PS 4 Community Health, Safety and Security	*Yes*	• Air Quality • Noise • Transport • Traffic	• Monitor H_2S emissions to protect both workers and nearby residents (ESMP #13) • Implement a Noise Management Plan (ESMP #2) Monitor noise levels and implement corrective action plan if needed

IFC Performance Standard	Triggered by Project	Project Issues	Recommended Actions[1]
		• Induced Micro-Seismicity • Influx • Recreation • Well Closure	(ESAP #13 and ESMP #11) • Implement Transportation and Traffic Management Plan (ESMP #10), which confirms SVGCL responsibility to repair any damage to roads or other facilities during Project construction and develop and implement a Journey Management Plan (ESAP #9) • Monitor potential for induced micro-seismicity (ESMP #11) • Provide a security fence around the drill pad (ESMP #8) • Implement Socioeconomic and Community Health Management Plan to manage influx and recreation risks (ESMP #8) • Implement Decommissioning Management Plan if needed (i.e., Pad W1 not productive) (ESMP #6)
PS 5 Land Acquisition and Involuntary Resettlement	*Yes*	• Land Acquisition • Physical Resettlement • Economic Displacement	• Finalize Project design so RAP can be updated, including expanding/completing census and negotiating compensation for economic displacement (ESAP #5)
PS 6 Biodiversity Conservation and Sustainable Natural Resource Management	*Yes*	• St. Vincent Parrot • Terrestrial endemic species • Aquatic endemic species	• Implement Biodiversity Management Plan (ESMP #7) • Conduct a St. Vincent Parrot census in the Project Area (ESAP #8) • Avoid to the extent possible starting construction during the St. Vincent Parrot breeding season (from January to June) (ESAP #12)
PS 7 Indigenous Peoples	*No*	Not applicable - the Project would not affect indigenous peoples.	None
PS 8 Cultural Heritage	*Yes*	• Byera Tunnel • Orange Hill Aqueduct • Unknown sites	• Develop and implement a Journey Management Plan to protect the Byera Tunnel and Orange Hill Aqueduct (ESAP #9) • Implement the Cultural Heritage Resources Management Plan (ESMP #9)

ESAP = Environmental and Social Action Plan; ESMP = Environmental and Social Management Plan; ESMS = Environmental and Social Management System; H&S = Health and Safety; H_2S = hydrogen sulfide; PS = Performance Standard; SVGCL = St. Vincent Geothermal Company Limited; RAP = Resettlement Action Plan

[1] Refers to the Environmental and Social Action Plan (ESAP) (see Table 8-2), and the Environmental and Social Management Plan (ESMP) (see Appendix E)

8.2 RECOMMENDATIONS

This section presents ERM's recommendations relative to exploratory drilling at sites W1 and W3 in the form of an ESAP; as well as actions that SVGCL could undertake now in anticipation of moving forward into Phase II of the St. Vincent Geothermal Project.

8.2.1 Environmental and Social Action Plan

An ESAP identifies and prioritizes actions needed to address gaps in the Project design, ESIA, management plans, management systems, or stakeholder engagement process to bring a Project in line with international standards. Table 8-2 provides the actions required to bring the Project fully into conformance with the IFC PSs.

As indicated in this ESIA, the SVGCL's intention is to develop just one exploratory drill pad site. The preferred site is W1, and the ESAP below is structured to focus on key actions for the development of Pad W1. However, if Pad W1 is not successful, SVGCL intends to drill exploratory wells at Pad W3. As described in the ESAP below, there are additional actions required before construction begins at Pad W3 in order to comply with the IFC PSs.

Table 8-2: Project Environmental and Social Action Plans

No.	Action Plan Item	Objectives/Comments	Responsible Party	Timetable for Action to be Completed
Prior to Construction at Pad W1				
1	Stakeholder Engagement	Complete, disclose, and implement a Stakeholder Engagement Plan (SEP) to ensure 1) consultation and disclosure of ESIA/ESMP documentation, and 2) ongoing community engagement during Construction, Drilling, and Testing.	SVGCL	Prior to Construction at Pad W1
2	Grievance Mechanism	Establish an understandable and transparent grievance mechanism that is culturally appropriate and readily accessible, and at no cost and without retribution for Project-Affected Communities, and people who would be physically or economically displaced by the Project.	SVGCL	Prior to CDB Board Approval
3	Government of St. Vincent and the Grenadines (SVG) approval.	Secure Government of SVG approval of the Project.	SVGCL	Prior to CDB Board Approval
4	Environmental and Social Management System (ESMS)	Prepare, for lender review and approval, an ESMS for the Project to ensure ongoing compliance with requisite environmental, health and safety and social standards (i.e., adopted environmental, social, health and safety standards (ESHS), Company commitments as outlined in ESIA) and to meet SVG legal requirements, IFC Performance Standards, and EHS Guidelines.	SVGCL	30 days prior to start of construction
5	Resettlement Action Plan (RAP)	Finalize Project land acquisition and economic displacement requirements, finalize RAP consistent with IFC Performance Standards, develop a compensation strategy, and implement the RAP.	SVGCL	Prior to land acquisition and construction
6	Soil Erosion and Sediment Control Plan	Prepare detailed Soil Erosion and Sediment Control Plan for all construction at Pad W1, including the water system, drill pad, and injection pad.	SVGCL	Prior to construction at Pad W1
7	Worker Code of Conduct	Prepare a Worker Code of Conduct to minimize conflicts with local communities.	SVGCL	Prior to construction at Pad W1
8.	St. Vincent Parrot Census	Conduct a St. Vincent Parrot population census in the forests surrounding the pad sites to establish a baseline to monitor the impacts of the Project on this species	SVGCL	Prior to construction at Pad W1
9	Journey Management Plan	Prepare Journey Management Plan to minimize traffic and safety issues associated with transported construction equipment and materials to Pad W1 for review and approval by the SVG .	SVGCL	Prior to the transport of equipment or materials to Pad W1
10	Community Liaison Officer (CLO)	Hire a CLO to help keep the community informed about the Project and to manage the Grievance Mechanism.	SVGCL	Prior to construction at Pad W1
During Project Construction, Drilling, and Testing at Pad W1				
11	Environmental and Social Management Plan (ESMP)	Implement the ESMP.	SVGCL	Throughout Phase I

No.	Action Plan Item	Objectives/Comments	Responsible Party	Timetable for Action to be Completed
12	Construction Timing	To the extent possible, avoid starting construction during the St. Vincent Parrot breeding season (from January to June) and avoid Stage 4 large water withdrawals from the Rabacca River during the low flow period (from January to March).	SVGCL	During construction at Pad W1
13	Noise and Air Monitoring	Install noise meters and H_2S monitors and confirm actual noise levels and H_2S concentrations comply with IFC Performance Standards and EHS Guidelines. If not, development an Action Plan to address this non-compliance.	SVGCL	Immediately upon commencement of well drilling. Provide monitoring report to lenders within 2 weeks.
14	Construction Monitoring and Reporting	Submit monitoring reports relating to compliance with applicable standards and monitoring requirements including air emissions, ambient air quality, noise and vibrations, effluent quality, groundwater quality, and solid wastes.	SVGCL	Quarterly reporting during Construction and Testing
Prior to Construction at Pad W3				
15	ESIA and RAP Addenda	Finalize design (e.g., land acquisition needs and provision of process water) and prepare addenda to the ESIA and RAP (if necessary) to identify and evaluate impacts associated with land acquisition and water supply. This ESIA Addendum should demonstrate Project conformance with the IFC Performance Standards and amend any SVG permits if necessary.	SVGCL	Prior to construction at Pad W3
16	Soil Erosion and Sediment Control Plan	Prepare Soil Erosion and Sediment Control Plan for all construction at Pad W3, including the water system, drill pad, and injection pad.	SVGCL	Prior to construction at Pad W3
Concurrent with Construction at Pad W3				
17	Site 1 Decommissioning	Decommission Pad W1 if it is determined to be unacceptable.	SVGCL	During drilling at Pad W3

CDB = Caribbean Development Bank; CLO = Community Liaison Officer; ESHS = Environmental, Social, and Health and Safety; ESIA = Environmental and Social Impact Assessment; ESMP = Environmental and Social Management Plan; ESMS = Environmental and Social Management System; H_2S = hydrogen sulfide; IFC = International Finance Corporation; PS = Performance Standard; SVGCL = St. Vincent Geothermal Company Limited

8.2.2 *Recommendations for St. Vincent Geothermal Project Phase II*

It is the SVGCL's intent, assuming successful exploration, to use the exploratory wells as production wells to support a geothermal power plant. Preparation of this ESIA revealed data gaps and/or issues for Phase II of the St. Vincent Geothermal Project. ERM recommends that SVGCL begin to address these gaps/issues now so as to avoid any delays with the development of Phase II. The key data gaps/issues include:

- **Rabacca River Flow and Water Quality Data** – Limited flow data are available for the Rabacca River, the proposed water source for both exploratory drilling (Phase I) and power generation (Phase II). ERM recommends that SVGCL install a continuous water level recorder on the Rabacca River at the existing stream gauge near their proposed water intake to develop a flow record that would allow for better management of the water resource. Limited water quality data are also available for the Rabacca River. ERM recommends that SVGCL initiate monthly water quality sampling at least at one location upstream of Project influence and one location downstream of Project influence for the normal suite of parameters, including the anticipated chemical constituents of the geothermal liquids.
- **Meteorological Data** – Little meteorological data exists on St. Vincent and the little that was available was insufficient to conduct any air dispersion modelling. ERM recommends that SVGCL establish a meteorological station in the general vicinity of Pad W1, which would include hourly monitoring of at least temperature, precipitation, and wind speed and direction. These data would both support the air dispersion modelling required for Phase II and would complement and enhance the analytical value of the flow data discussed above.
- **Induced Micro-Seismicity Monitoring** – During scoping meetings and the draft Stakeholder Engagement Plan development, community members raised their concern regarding the potential of induced seismicity by the Project. Induced micro- seismicity has been reported in some cases internationally where geothermal development is carried out in seismic active zones; however, it is site-specific and relates to the geological conditions of each Project area (Bayer *et al.* 2013). In most cases, micro-seismic events have been of relatively small magnitude (i.e., magnitudes of less than 2.0), and by the time the energy reaches the surface, the vast majority are rarely felt (for further discussion, see Section 5.2.5, *Risk of Induced Micro-Seismicity*). Nonetheless, ERM recommends installing a Project seismic monitoring program or connecting with the existing SVG regional seismic monitoring network to obtain accurate baseline of seismic activity before the start of Phase II. Due to the relative small magnitude of induced micro-seismicity, ERM recommends that

instrumentation be able to detect events at least as small as magnitude 1.0.

- **Proposed Transmission Line Alignment** – as discussed in the Cumulative Impacts Assessment (Section 5.7), plans for the geothermal power plant currently involves two transmission lines to transmit electricity to the SVG electrical grid, one along the Windward Highway and one more inland. The inland route has the potential to impact important St. Vincent Parrot and other endemic and endangered species habitat. ERM encourages SVGCL and/or St. Vincent Electricity Services Limited to develop a Transmission Line Feasibility Study that considers route alternatives and begin to collect field data that would support a robust evaluation of Project alternatives.

8.3 SUMMARY

In summary, ERM concludes that the proposed Project would result in environmental and social impacts, but these impacts could be readily mitigated and managed, and the Project should comply with the requirements of the IFC PSs as long as the actions identified in the ESAP and the measures included in the ESMP are implemented.

ERM notes, however, that if the exploratory drilling at Pad W1 is not successful, and SVGCL needs to drill at Pad W3, additional engineering design (e.g., land acquisition needs and provision of process water), potentially an addendum to this ESIA to evaluate impacts associated with this additional design, and any necessary amendments to SVG permits would be required before Pad W3 could clearly be determined to conform with the IFC PSs.

9.0 REFERENCES

American National Standard Institute (ANSI). 1983. *S1.4-1983 – Specification for Sound Level Meters (S1.4 and S1.4a Reaffirmed by ANSI on 21 March 2006).*

American Petroleum Institute (API). 2014. *Recommended Practice for Field Testing Water-based Drilling Fluids.*

Anthony, Donald. Inventory of Fauna and Flora of Buccament Valley, St. Vincent and the Grenadines. St. Lucia: OECS Natural Resources Management Unit, 1997.

API. 2015. *Blowout Prevention Equipment Systems for Drilling Wells.*

Bailey, Brent. 2016. *Personal Communication*. February 25, 2016.

Bass, D. 2003. A Comparison of Freshwater Macroinvertebrate Communities on Small Caribbean Islands. *Bioscience* 53 (11) 1094-1100.

Bayer *et al*. 2013. Renewable and Sustainable Energy Reviews Journal – Review on life cycle environmental effects of geothermal power generation

Bullen, Ripley P. and Adelaide K. Bullen. 1972. *Archaeological Investigations on St. Vincent and the Grenadines West Indies.* American Studies Report 8. The William L. Bryant Foundation.

Callaghan, Richard. 2007. "Prehistoric settlement patterns on St. Vincent, West Indies. *Caribbean Journal of Science* 43 (1): 11-22. 2007.

Caribbean Community and Common Market (CARICOM). 2013. *Energy Policy in a Nutshell.*

Caribbean Conservation Association. St. Vincent and the Grenadines Country Environmental Profile. Caribbean Conservation Association, St. Michael, 1991.

Caribbean Hurricane Network. 2011. Climatology of Caribbean Hurricanes. Accessed 10 March 2016. Retrieved from: http://stormcarib.com/climatology/

Carrington, Sean. Wild Plants of Barbados, 2nd ed. Oxford: Macmillan Publishers Ltd. 2007

Carrington, Sean. Wild Plants of the Eastern Caribbean. London and Basingstoke: Macmillan Education Ltd, 1998.

Central Water and Sewerage Authority (CWSA). 2013. *Water resource and water production*. St. Vincent. Central Water and Sewerage Authority, Water Resource Management Unit. Kingstown.

Culzac-Wilson, L. 2008. St. Vincent and the Grenadines *in* Important Bird Areas in the Caribbean: Key sites for conservation. Cambridge, UK: Birdlife International (Birdlife Conservation Series No. 15).

CWSA. 2015. *Water Resource Management Unit. WRMU Data.* Accessed: 5 March 2016. Retrieved from:< http://www.cwsasvg.com/wrmu.html>

de Silva, Mark and Dianne Wilson. A Natural History of Mustique: A Field Guide to Common Flora, Fauna and Marine Species. Mustique Island: The Mustique Company Ltd., 2006.

FAO (Food and Agriculture Organization of the United Nations). 2016. *AQUASTAT. Saint Vincent and the Grenadines. Regional Report Year 2015*. Accessed: 5 March 2016. Retrieved from:< http://www.fao.org/nr/water/aquastat/countries_regions/vct/index.stm>

Feldmann, P., Barré, M-F, and Barré, N. Wild Orchids of St. Vincent and the Grenadines. W. I., 2011

Fraser, Adrian. 2016. *Saint Vincent and the Grenadines*. Encyclopedia Britannica. Electronic document available at http://www.britannica.com/place/Saint-Vincent-and-the-Grenadines#toc55431. Accessed February 2016.

Froese, R. and D. Pauly. Editors. 2016. FishBase. World Wide Web electronic publication. www.fishbase.org,

Fund, W., & Hogan, C. (2014). Bahamian mangroves. Accessed 22 March 2016. Retrieved from http://www.eoearth.org/view/article/150378 Gaston *et al*. 2013

Geothermal Consortium. 2015a. *Resettlement Action Plan: St. Vincent & the Grenadines Geothermal Development Project (Report No. 13002-10).* December 2015.

Geothermal Consortium. 2015b. *The Geothermal Development Project in Saint Vincent and the Grenadines: Stakeholder Engagement Plan, Version 03.* December 2015.

Gordon, Suzanne and Anne Hersh. 2005. *Searching for Sugar Mills: An Architectural Guide to the Eastern Caribbean*. Macmillan Publishers. Oxford, UK.

Graveson, Roger. www.saintlucianplants.com. 2012.

Hawthorne, William D. *et. al.* Caribbean Spice Island Plants. Oxford: Oxford Forestry Institute, 2004.

Inter-American Development Bank (IDB). 2015a. *Challenges and Opportunities for the Energy Sector in the Eastern Caribbean: Saint Vincent and the Grenadines Energy Dossier, Technical Note No. IDB-TN-853.* October 2015.

IDB. 2015b. *Managing the Impacts of IDB Projects on Cultural Heritage.* (IDB Technical Note 896). November 2015.

International Finance Corporation (IFC). 2007a. *Environmental, Health, and Safety General Guidelines.* April 30, 2007.

IFC. 2007b *Environmental, Health, and Safety Guidelines for Geothermal Power Generation.* April 30, 2007.

IFC 2012. *IFC Performance Standards on Environmental and Social Sustainability.*

IFC. 2013. *Good Practice Handbook - Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets*

International Union for the Conservation of Nature (IUCN) 2016

ISO 1996. Acoustics – Attenuation of sound During Propogation Outdoors, Part 2: General Method of Calculation.

Murray, Reynold 2014. *Baseline Survey of the Environmental Impact Assessment of the Proposed La Soufriere Geothermal Field, North of St. Vincent.* January 2014.

National Environmental Advisory Board and Ministry of Health and the Environent 2000. *Initial National Communication on Climate Change, St. Vincent and the Grenadines.* November 2000.

Neal, J.W., C.G. Lilyestrom and T.J. Kwak 2009. Factors Influencing Tropical Island Freshwater Fishes: Species, Status, and Management Implications in Puerto Rico. *Fisheries* 34 (11) pp. 546-554

Nippon Koei Geothermal Engineering Co., Ltd., and SRED. 2015. *Data Collection Survey for Geothermal Development in Saint Vincent and the Grenadines: Geothermal Development Project in SVG, Draft ESIA Scoping Report.* December 2015.

Organization of American States (OAS). 2001. *National Report. Integrating Management of Watersheds and Coastal Areas in Sids of the Caribbean*. Accessed: 16 March 2016. Retrieved from:< http://www.oas.org/reia/IWCAM/pdf/St.%20Vincent%20and%20the%20Grenadines/St.%20Vincent%20and%20the%20Grenadines%20National%20Report.PDF>

Organisation of Eastern Caribbean States (OECS) 2015. *The OECS, About the Organisation.* Accessed on: March 22, 2016. Available at: http://www.oecs.org/about-the-oecs/institutions/38-about-the-organisation

Ortega, C. 2012. Effects of Noise Pollution on Birds: A Brief Review of our Knowledge. Ornithological Monographs No. 74 pp 6-22.

Platteeuw and Henkens 1997

Powell, R. and Henderson, R. W. The St. Vincent (Lesser Antilles) Herpetofauna: Conservation Concerns. *Applied Herpetology* 4: 295-312, 2000.

Providence, FitzGerald. Protecting our Protected Areas (St. Vincent).

Raffaele, Herbert *et. al.* Birds of the West Indies. New Jersey: Princeton University Press, 2003.

PreventionWeb. 2016. *Saint Vincent and the Grenadines. Disaster and Risk Profile*. Accessed: 17 March 2016. Retrieved from:<http://www.preventionweb.net/countries/vct/data/>

Reykjavik Geothermal (RG) 2013. *A Geothermal Desk Study for Mt. Soufriere, St. Vincent (Report No. 13002-01).* April 2013.

Rich and Longcore 2006

_____. 2015a. *Drilling Targets and Location of Drill Pads - Geoscientific Analyses (Report No. 13002-05*). March 2015.

_____. 2015b. *Nominal Well Design and Geological Prognosis for Well SVG-01, Mt. Soufriere, Saint Vincent and the* Grenadines (Report No. 13002-06). September 2015.

_____. 2015c. *Nominal Well Design and Geological Prognosis for Well SVG-02, Mt. Soufriere, Saint Vincent and the Grenadines (Report No. 13002-07*). September 2015.

_____. 2015d. *Remote Sensing Report (Report No. 13002:4*). February 2015.

_____. 2015e. *Resistivity Study of Mt. Soufriere, Saint Vincent and the Grenadines (Report No. 13002-03).* February 2015.

RG and EC 2016. *Request for Proposal for the Supply of Drilling Services Geothermal Development St. Vincent.*

RG and LPH (Reykjavik Geothermal and Light & Power Holdings/Emera) 2013. *ESIA for Geothermal Exploration in St. Vincent: Scoping Report*. November 2013.

Roberston, Richard E.A. 2003. *Making Use of Geology-the Relevance of Geology and Geological Information to the Development Process in St. Vincent and the Grenadines*. Accessed: 16 March 2016. Retrieved from:< http://www.open.uwi.edu/sites/default/files/bnccde/svg/conference/papers/robertson.html>

Rouse, Irving. 1992. *The Tainos: Rise and Decline of the People Who Greeted Columbus.* Yale University Press. New Haven.

Simmons and Associates, Inc. Draft National Biosafety Strategy and Action Plan for St. Vincent and the Grenadines. Report prepared for the Government of St. Vincent and the Grenadines, 2000.

Snyder, M.N.; E.P. Anderson; and C.M Pringle. 2011. A Migratory Shrimp's Perspective on Habitat Fragmentation in the Neptropics: Extending our knowledge from Puerto Rico. *New frontiers in crustacean biology*: 169-182.

Stantec. 2015. *Feasibility Study to Assess Infrastructure Capacity for Geothermal Development at La Soufriere Volcano, St. Vincent, W.I.* March 2015.

StormCARIB 2011. *Climatology of Caribbean Hurricanes. St. Vincent (TVSV).* stormCARIB. Carribean Hurricane Network. Accessed 17 March 2016. Retrieved from:< http://stormcarib.com/climatology/TVSV_all_isl.htm>

St. Vincent and the Grenadines (SVG) 2015. *Intended Nationally Determined Contributions Communicated to the UNFCC.* November 18, 2015.

SVG Statistics Office, Population Census Data. 2012 (retrieved on March 8, 2016 from http://www.stats.gov.vc/CensusSurveys.aspx.aspx)

Teruel, R. Redescription of *Tityus pictus* Pocock, and *Tityus smithii* Pocock, 1893, with notes on the *Tityus* species from the Lesser Antilles (Scorpiones: Buthidea)., 2011 http://www.science.marshall.edu/fet/euscorpius/p2011_125.pdf. Accessed March 2016.

The Engineering ToolBox. 2016. *Densities and molecular weights of some common gases.* Retrieved on March 30, 2016 from http://www.engineeringtoolbox.com/gas-density-d_158.html

The International Volcanic Health Hazard Network (IVHHN). 2016. Sulphur Dioxide (SO_2) Existing Guidelines. Durham University. Accessed 11 March 2016. Retrieved from: http://www.ivhhn.org/index.php?option=com_content&view=article&id=82

Treglia, Micahel L. An Annotated Checklist of the Amphibians and Reptiles of St. Vincent, West Indies. *Iguana.* Vol 13 Number 4. December 2006. Pp 253-263

US Department of Energy 2012. Protocol for Addressing Induced Seismicity Associated with Enhanced Geothermal Systems 2012.

USGS (2014), Shuttle Radar Topography Mission (SRTM), 1 Arc Second scene SRTM1N13W062V3, Coordinates: 13, -62, Unfilled Unfinished 2.0, Global Land Cover Facility, University of Maryland, College Park, Maryland, February 2000. Retrieved from: http://glcf.umd.edu/data/srtm/

Washington State Department of Transportation (WSDOT), 2015. Advanced Training Manuel Biological Assessment Preparation for Transportation Projects, Chapter 7.0, Version 10-2015

World Bank Growth Development Indicators, retrieved on March 8, 2016 from http://databank.worldbank.org/data/reports.aspx?source=2&country=VCT&series=&period=

World Bank 2016. 2015 World Development Indicators: Transport Services. Table 5.10. Retrieved from http://wdi.worldbank.org/table/5.10#. Accessed March 10, 2016.

World Bank Group: Climate Change Knowledge Portal for Development Practitioners and Policy Makers. 2016. *Saint Vincent And The Grenadines: Climate: Historical*. Accessed 10 March 2016. Retrieved from: http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Latin%20America&ThisCCode=VCT

World Bank Group. 2016. *After Hurricane Thomas, Saint Vincent and the Grenadines Strengthens its Resilience*. Accessed 17 March 2016. Retrieved from: <http://www.worldbank.org/en/results/2014/09/25/hurricane-thomas-saint-vincent-grenadines-strengthen-reslience>

[Name Not Listed]. 2016. *Personal Communication*. Representative from Physical Planning Unit. February 25, 2016.

1.0 APPENDIX A: NOISE

1.1 NOISE TERMINOLOGY

Noise is generally defined as unwanted sound. Airborne sound levels in decibels (dB) are presented on a logarithmic scale to account for the large range of acoustic pressures that the human ear is exposed to. A dB is defined as the ratio between a measured value and a reference value usually corresponding to the lower threshold of human hearing defined as 20 micro Pascals (μPa). The human ear does not perceive every frequency with equal loudness; therefore, spectrally varying sounds are often adjusted with a weighting filter. The A-weighted filter is applied to compensate for the frequency response of the human auditory system and is represented in dBA. Therefore, unless otherwise noted, all decibel measurements presented in this report are A-weighted (dBA) on the logarithmic scale.

Two common ways of characterizing sound levels are as follows: sound power level (LW) and sound pressure level (LP). The LW is a measure of the total power radiated by a source. The LW of a source is a fundamental property of the source and is independent of the surrounding environment. The LP is the level of sound pressure, as measured at a distance by a standard sound level meter with a microphone. This differs from LW in that it is the received sound as opposed to the sound intensity at the source. For A-weighted sound power levels and sound pressure levels, the LW and LP are denoted as LWA and LPA, respectively.

An inherent property of the logarithmic dB scale is that the sound pressure levels of two separate sources are not directly additive. For example, if a sound of 60 dBA is added to another sound of 60 dBA, the result is a 3-decibel increase (or 63 dBA), not an arithmetic doubling of 100 dBA. Typically, noise levels vary over time and the following indices are used to account for these variations:

- **Leq**: is the steady, continuous equivalent sound pressure level, which has the same acoustic energy as the actual varying sound levels over the same time period;
    - **Leq(day):** is the daytime Leq level (07:00 to 22:00 hours);
    - **Leq(night):** is the nighttime Leq level (22:00 to 07:00 hours);
- **Lx:** identifies the sound level that is exceeded "x" percent of the time over a measurement period; and
- **Ldn:** is the day-night average sound pressure level with a 10 dB penalty added for nighttime noise to compensate for nighttime sensitivity. If both the Leq(day) and Leq(night) are measured, then the Ldn is calculated using the formula:

$$L_{dn} = 10log_{10}(\frac{15}{24}10^{L_{eq(day)}/10} + \frac{9}{24}10^{(L_{eq(night)}+10)/10})$$

The perceived increase in loudness of a sound does not correspond directly to numerical increase in dBA values. Typically, an increase of less than 3 dBA is barely noticeable, an increase of 5 dBA is noticeable, an increase of 10 dBA is perceived as a doubling in apparent loudness, and an increase of 20 dBA is perceived as a four-fold increase in apparent loudness.

1.2 INSTRUMENTATION AND METHODOLOGY

Ambient noise measurements were conducted at seven measurement locations (N1 to N7) between February 21 and 25, 2016 using the following instruments:

- Quest SoundPro DL Type I Sound Level Meter (SLM)
- Quest QC-10 Acoustic Calibrator
- Remote Microphone

The SLM has an operating range of 5 dB to 140 dB, and an overall frequency range of 8 to 20,000 hertz (Hz) and meets or exceeds all requirements set forth in the American National Standards Institute standards for Type 1 SLMs for quality and accuracy/ precision (ANSI S1.4-1983; ANSI 1983). All instrumentation utilized during the noise survey had current laboratory certification, which are available upon request.

The microphone and windscreen were tripod-mounted at an approximate height of 5 feet above grade and away from effects of reflective surfaces. In addition, the sound level analyzer microphones were protected from wind-induced self-noise effects by a 7-inch diameter foam windscreen made of specially prepared open-pored polyurethane. The SLM was calibrated at the beginning and end of the measurement period using the acoustic calibrator and following procedures described in The Quest SoundPro User Manual. Pre-and-post study calibrations were conducted to ensure the instrument was functioning within the required range (114 dB at 1000 Hertz [Hz]).

Weather observations for the measurement period were obtained from the www.weather.com , which provided information on the daily temperature and humidity in Kingstown, SVG. During daytime measurement period, there was no precipitation, sky conditions ranged from sunny with some clouds (partly cloudy) to overcast, temperatures ranged from 80 to 86 degree Fahrenheit (˚F) and relative humidity ranged from 60 to 65 percent, and average wind speeds ranged from 5 to 10 miles per hour (mph) in the east to west direction. During nighttime measurement period, there was no precipitation, skies were mostly cloudy, the temperature was 77 ˚F, relative humidity was 50 percent, and average wind speeds ranged from 5 to 15 mph in the east to west direction.

Sound pressure level data were collected for full (1/1) octave bands spanning the frequency range of 16 Hz to 16,000 Hz. The SLM was programmed to record sound pressure levels in intervals of 1-minute over a period of 5 to 15 minutes at each location using A-weighted Leq sound levels on fast response. Aside from the Leq metric, other sound level metrics recorded include maximum sound levels (Lmax), and percentile levels (L10, L50, and L90). To the extent practicable, unusual or extraneous noise such as noise from lawnmowers or nearby construction, activity was avoided during the ambient noise measurement periods. Observations of existing noise sources were also recorded during the measurement period at each location. Following the completion of the measurement period, all measured data were downloaded to a computer for the purposes of storage and further analysis.

1.3 NOISE SURVEY DATA

Table 11-1: Summary of NML Site Description, Weather Conditions, and Field Observations

Date and Start Time	Measurement Duration (Mins)	Period	Site ID	Site Description	Weather Conditions						Field Observations and Dominant Noise Sources
					Temp (˚F)	RH (%)	Wind Speed (mph)	Wind Direction	Sky Condition	Ground Condition	
2/23/2016 5:07pm	15	Day	N1	Along the road next to a historic sugar mill ruin and active mental health facility/hospital. Instrument set up on flat, brick and plaster pad with sight lines to mental hospital, historic resource, and road. Road partially blocked by chain link vence covered in vines.	86	60	<5	W	Overcast	Brick	Traffic noise, distant radio, people talking at a distance.
2/23/2016 5:57pm	15	Day	N2	Edge of the road at the entrance to a Horticulture Research and Development facility. Located across the street from the town of New Orange Hill. Location seperated from project area by high hills.	86	60	<5	W	Overcast	Asphalt	Cars, people talking outside houses, ocean, wind
2/24/2016 1:17pm	15	Day	N3	Bamboo Range Visitor Center at hiking trail head leading to La Soufriere. Area is upslope from Well Pad 1 and seperated from the well pad by a stand of trees and bamboo.	86	65	<5	W	Partly Sunny	Grass	Wind and birds
2/24/2016 2:20pm	15	Day	N4	Rural roadside near Well Pad 1. Set up across the road from a farmer worker shed. 3 men were living in the shed at the time of sampling but it appears to be a seasonally or semi-permanently occupied building for farm workers.	86	65	5-10	W	Partly Sunny	Grass	Goats bleating, wind, leaves rustling, birds
2/24/2016 3:32pm	15	Day	N5	Set up in field next to farm hut used during the day as a rest and eating area by a local farmer. S	85	65	5-10	W	Partly Sunny	Grass	Goats bleating, wind, leaves rustling, birds
2/24/2016 4:36pm	15	Day	N6	Next to house currently under construction adjacent to reinjection pad for Well 3.	83	60	5-10	W	Cloudy	Dirt	Cattle baying in the distance, wind rustling leaves
2/24/2016 5:43pm	15	Day	N7	Rural roadside near next to banana processing hut. Hut is not occupied but is used by workers in the surrounding banana plantations to wash bananas and take breaks.	80	60	5	W	Cloudy	Dirt	People talking as they pass by, wind, distant dogs barking, birds
2/25/2016 5:16am	15	Night	N7	Rural roadside near next to banana processing hut. Hut is not occupied but is used by workers in the surrounding banana plantations to wash bananas and take breaks.	77	50	10-15	W	Cloudy	Dirt	Insects, wind rustling banana leaves

Date and Start Time	Measurement Duration (Mins)	Period	Site ID	Site Description	Weather Conditions						Field Observations and Dominant Noise Sources
					Temp (˚F)	RH (%)	Wind Speed (mph)	Wind Direction	Sky Condition	Ground Condition	
2/25/2016 5:39am	15	Night	N6	Next to house currently under construction adjacent to reinjection pad for Well 3.	77	50	10-15	W	Cloudy	Dirt	Roosters crowing, wind rustling leaves, birds, insects
2/25/2016 6:08am	15	Night	N1	Along the road next to a historic sugar mill ruin and active mental health facility/hospital. Instrument set up on flat, brick and plaster pad with sight lines to mental hospital, historic resource, and road. Road partially blocked by chain link vence covered in vines.	77	50	10-15	W	Cloudy	Brick	Birds, traffic noise, people walking by, talking in hospital, goats bleating, a car stopped for 1 minute with radio blasting
2/25/2016 6:30am	15	Night	N2	Edge of the road at the entrance to a Horticulture Research and Development facility. Located across the street from the town of New Orange Hill. Location seperated from project area by high hills.	77	50	10-15	W	Cloudy	Asphalt	Wind, birds, passing cars
2/25/2016 6:59am	15	Night	N4	Rural roadside near Well Pad 1. Set up across the road from a farmer worker shed. 3 men were living in the shed at the time of sampling but it appears to be a seasonally or semi-permanently occupied building for farm workers.	77	50	10-15	W	Cloudy	Grass	Very light mist rain, dog barking, distant rooster crowing, men talking across the street.

Table 11-2. Summary of Noise Sampling Results

Date and Start Time	Measurement Duration (Mins)	Period	Site ID	Measured Sound Level in dB per Octave Band Frequency in Hertz											Overall A-weighted Sound Level (dBA)	Percentile Sound Levels (dBA)			Maximum Sound Level
				16 Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	16000 Hz	Leq	L90	L50	L10	Lmax
2/23/2016 5:07pm	15	Day	N1	24	29.0	48.5	45.6	47.4	48.1	50.7	49.5	44.9	39.7	37.6	56.8	43.3	46.2	57.2	77.8
2/23/2016 5:57pm	15	Day	N2	22.5	28.4	35.5	43.5	50.4	53.6	57.1	55.7	51.6	42.6	37.3	61.6	44.5	46.7	58.7	89.4
2/24/2016 1:17pm	15	Day	N3	25.2	20.9	21.0	24.4	29.8	33.1	35.2	36.9	38.3	37.5	36.2	44.5	39.2	42.4	46.9	62.3
2/24/2016 2:20pm	15	Day	N4	23.3	25.4	26.0	27.8	33.3	36.7	39.3	39.2	39.7	40.0	36.3	46.9	39.2	43.9	48.9	70.4
2/24/2016 3:32pm	15	Day	N5	25.2	23.5	26.7	28.9	32.2	32.2	32.1	32.3	34.2	36.5	36.3	41.6	36.2	39.0	44.0	57.8

Date and Start Time	Measurement Duration (Mins)	Period	Site ID	Measured Sound Level in dB per Octave Band Frequency in Hertz											Overall A-weighted Sound Level (dBA)	Percentile Sound Levels (dBA)			Maximum Sound Level
				16 Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	16000 Hz	Leq	L90	L50	L10	Lmax
2/24/2016 4:36pm	15	Day	N6	23.8	21.4	24.7	26.5	26.3	27.4	29.1	33.0	34.9	36.7	36.3	40.6	36.2	36.2	43.0	63.7
2/24/2016 5:43pm	15	Day	N7	21.0	21.4	23	27	27.4	27.2	30.1	32.3	34.1	36.3	36.3	39.4	36.2	36.2	40.7	60.6
2/25/2016 5:16am	15	Night	N7	25.9	24.7	24.0	23.0	25.7	31.4	34.2	34.8	36.2	38.1	42.0	45.4	39.1	42.7	48.5	62.0
2/25/2016 5:39am	15	Night	N6	22.4	22.2	23.9	24.3	25.0	27.8	33.3	36.1	42.5	36.5	45.5	48.3	42.9	48.4	50.3	56.2
2/25/2016 6:08am	15	Night	N1	21.3	23.7	34.9	40.0	44.3	50.4	50.4	51.4	49.6	42.3	36.3	57.1	44.5	48.0	60.3	79.7
2/25/2016 6:30am	15	Night	N2	22.8	26.8	38.8	40.4	47.7	49.5	55.6	50.7	49.3	41.6	36.5	58.8	45.1	47.3	59.2	82.4
2/25/2016 6:59am	15	Night	N4	19.0	17.1	20.5	26.0	29.2	33.3	34.3	36.1	39.0	38.8	36.3	43.7	36.2	38.2	46.3	67.4

Vegetation Species Documented in the Study Area

Species (***Scientific name***, **common name**)	**Location Where Observed (WP1, WP3, RS1, RS3, general study area)**	**Comments**
Acromia aculeata Gru gru	WP1, WP3	
Aegiphila martinicensis Ram goat bush	WP1, WP3	
Annona muricata Soursop	WP3	
Arthostylidium excelsum Wild bamboo	WP1, WP3	
Alpinia purpurata River lily	WP1	
Anthurium acaule	WP3	
Artocarpus heterophyllus Jack fruit	WP3	
Averrhoa carambola Carambola, star fruit	WP3	
Bambusa vulgaris Bamboo	WP1, WP3	
Begonia pensilis	General study area	Local endemic
Bidens pilosa Spanish needle, needlegrass	WP3	
Bixa orellana Roukou, annato	WP3	
Boehmeria ramiflora	WP1	
Bromeliad sp. Bromeliad	WP3	
Cajanus cajan Pigeon peas	WP3	
Calophyllum calaba Galba	WP1	
Carica papaya Pawpaw	WP1, WP3	
Capraria biflora West Indian Tea	WP3	
Cecropia peltata Trumpet tree	WP1, WP3	
Chromolaena odorata Baby bush, Christmas bush	WP3	
Chrysobalanus icaco Fat pork	WP3	

Species (*Scientific name*, **common name**)	**Location Where Observed (WP1, WP3, RS1, RS3, general study area)**	**Comments**
Cissus verticillata Pudding vine	WP1, WP3	
Cissampelos pareira Graveyard vine	WP1	
Citrus reticulate Tangerine	WP3	
Citrus sinensis Orange	WP3	
Cleome aculeata Ground dove fifi	WP1	
Clusia rosea Monkey goblet	WP1	
Cocos nucifera Coconut	WP1. WP3	
Codiaeum variegatum Croton	WP3	
Coffea sp. Coffee	WP3	
Colocasia esculenta Dasheen	WP3	
Commelina diffusa Water grass	WP1, WP3	
Cordia curassavica Black sage	WP1, WP3	
Cordia sulcata Manjack	WP1, WP3	
Croton betulinus Broombush	WP3	
Cyperus digitatus Reed	WP3	
Desmodium triflorum Bud grass	WP3	
Dieffenbachia seguine Dumb cane	WP3	
Dioscorea alata Boba's vine	WP1	
Dioscorea polygonoides Yam vine	WP3	
Dryopteris felix-mas Fern	WP3	
Eclipta prostata	WP3	

Species (*Scientific name*, common name)	**Location Where Observed (WP1, WP3, RS1, RS3, general study area)**	**Comments**
Conga lala		
Eleusine indica Lawn grass	WP3	
Emilia fosbergii Rabbit feed	WP1, WP3	
Emilia sonchifolia Rabbit feed	WP3	
Endlicheria sericea White sweetwood	WP3	
Eucalyptus eglupta Eucalyptus	WP1	
Eucalyptus sp. Eucalyptus	WP1	
Euphorbia cyathophora Milk bush, wild poinsettia	WP3	
Ficus citrifolia White fig	WP1, WP3	
Ficus insipida Red fig	WP3	
Gliricidia sepium Glory cedar	WP3	
Gonzalagunia spicata (=hirsuta) Blueberry,ink bush	WP1	
Henriettia triflora Ashes wood	WP1, WP3	Regional endemic
Inga ingoides Spanish ash	WP1, WP3	
Ipomoea tiliacea Running vine	WP1, WP3	
Lantana camara Lantana	WP1, WP3	
Laportea aestuans Stinging nettle	WP1	
Leontis nepetifolia John cutlass, bald-head-cashie	WP3	
Lepianthes peltata Cow heel	WP3	
Lobelia cirsiifolia Burn eye	WP1	Regional endemic
Ludwigia octovalvis Many-seed	WP3	
Luffa aegyptiaca	WP1	

Species (***Scientific name*, common name)**	**Location Where Observed (WP1, WP3, RS1, RS3, general study area)**	**Comments**
Loofah		
Mangifera indica Mango	WP1, WP3	
Melochia nodiflora Red dialthea, broom	WP1, WP3	
Mimosa pudica Mimosa	WP1, WP3	
Momordica charantia Koreila	WP1, WP3	
Musa sp. Banana	WP1, WP3	
Nautilocalyx melittifolius	WP1, WP3	
Ocotea eggersiana Black sweetwood	WP1, WP3	Regional endemic
Palicourea croceoides Red palicorea	WP1, WP3	
Parthenium hysterophorus White head	WP3	
Passiflora edulis Passion fruit	WP3	
Passiflora laurifolia Bell apple	WP1	
Passiflora suberosa Susumba	WP1	
Pennisetum purpureum Elephant grass	WP1	
Persea Americana Avocado	WP3	
Peperomia pellucida Shine bush	WP3	
Philodendron panduriforma Philodendron	WP1	
Phyllanthus amarus White seed-under-leaf	WP3	
Piper dilatatum Joint bush	WP1, WP3	
Pityrogramma calomelanos Tattoo fern	WP1, WP3	
Polystichum aculeatum Fern	WP1	
Pseudelephantopus spicatus	WP3	

Species (*Scientific name*, common name)	**Location Where Observed (WP1, WP3, RS1, RS3, general study area)**	**Comments**
Psidium guajava Guava	WP3	
Pueraria phaseoloides Kudzu vine	WP1, WP3	
Ricinus communis Castor oil plant	WP1	
Sapium grandulosum (=caribaeum) Burn lime	WP1, WP3	Regional endemic
Pouteria semicarpifolia Contrevent	WP1	Regional endemic
Scleria secans Razor grass	WP3	
Sechium edule Christophene	WP3	
Selaginella sp. Selaginella	WP1	
Setaria parviflora Nut grass	WP1	
Sida acuta Broom	WP1, WP3	
Simarouba amara Bird food	WP1	
Smilax guianensis Wiss vine	WP1, WP3	Regional endemic
Solanum torvum Shushuba, wild	WP1, WP3	
Spermacoce ocymifolia	WP1, WP3	
Spermacoce verticillata	WP3	
Sphagneticola trilobata Wedelia	WP1, WP3	
Spondias mumbin Hog plum	WP3	
Stachytarpheta jamaicensis Verveine	WP1, WP3	
Syzigium malaccense Plum rose	WP1	
Swietenia macrophylla Broad-leaf mahogany	WP1	
Tetrazygia discolor Candle wood	WP3	Regional endemic

Species (*Scientific name*, common name)	**Location Where Observed (WP1, WP3, RS1, RS3, general study area)**	**Comments**
Turpinia occidentalis Bitter ash	WP1	
Vernonia cinerea Rabbit feed, little ironweed	WP3	
Vitex divaricata Bastard fiddlewood	WP3	
Wedelia calycina Wild marigold	WP1	
Xanthosoma sp. Tannia	WP1,WP3	

Fauna Species Documented in the Study Area

Species **(*Scientific name*, common name)**	**Location Where Observed (WP1, WP3, RS1, RS3, general study area)**	**Comments**
Birds		
Allenia fusca Scaly-breasted Thrasher	WP1, WP3, RS2	
Amazona guildingii St. Vincent Parrot	WP1, WP3, RS2	IUCN Vulnerable Local endemic
Buteo platypterus Broad-winged Hawk	WP1, WP3, RS1	
Buteogallus anthracinus Common Black-hawk	WP1, WP3	
Cinclocerthia ruficauda Brown Trembler	WP1, WP3, general study area	
Coccyzus minor Mangrove Cuckoo	WP1, WP3, RS1	
Coereba flaveola Bananaquit (St. Vincent race)	WP1, WP3, RS1	
Columbina passerina Common Ground-dove	WP3	
Crotophaga ani Smooth-billed Ani	RS1, RS2	
Egretta caerula Little blue heron	WP3	
Elaenia flavogaster Yellow-bellied Elaenia	WP1, WP3, RS1, RS2	
Eulampis holosericeus Green-throated Carib	WP1	
Eulampis jugularis Purple-throated Carib	WP1, WP3	
Loxigilla noctis Lesser Antillean Bullfinch	WP1, WP3	
Myiarchus nugator Grenada Flycatcher	WP1, WP3, RS2	Regional endemic
Orthorhyncus cristatus Antillean Crested Hummingbird	WP1, WP3, RS1	
Patagioenas squamosa Scaly-naped Pigeon	WP1, WP3, RS2	
Tangara cucullata Lesser Antillean Tanager; Princebird	WP3	Regional endemic
Tiaris bicolor Black-faced Grassquit	WP1, WP3, RS1, RS2	

Species **(*Scientific name*, common name)**	**Location Where Observed (WP1, WP3, RS1, RS3, general study area)**	**Comments**
Troglodytes aedon musicus St. Vincent House Wren	WP1, WP3, RS1	
Tyrannus dominicensis Gray Kingbird; Piperee	WP1, WP3, RS1, RS2	
Vireo altiloquus Black-whiskered Vireo	WP1, WP3, RS1	
Mammals		
Dasypus novemcinctus Nine-banded armadillo	WP1	
Didelphis marsupialis insularis Manicou	WP3	
Herpestes auropunctus Mongoose	General study area	
Mus musculus House mouse	WP1, WP3	
Rattus rattus Black rat	WP1, WP3	
Unidentified fruit bat	WP1	
Reptiles		
Anolis griseus St. Vincent tree anole	WP1, WP3	Local endemic
Anolis trinitatus St. Vincent bush anole	WP1, WP3	Local endemic
Gymnophthalmus underwoodi Smooth-scaled worm lizard, Underwood's spectacled tegu	WP1	
Sphaerodactylus vincenti Windward dwarf gecko	WP1, WP3	Regional endemic
Mastigodryas brusei White snake, Windward racer	WP3	Regional endemic
Amphibians		
Eleutherodactylus johnstonei Lesser Antillean whistling frog	WP3	
Pristimantis shrevei St. Vincent whistling frog	WP1	IUCN Endangered Local endemic
Rhinella marina Cane toad	WP3	
Invertebrates		
Anartia jatrophae Biscuit (butterfly)	WP1, WP3	

Species (*Scientific name*, **common name)**	**Location Where Observed (WP1, WP3, RS1, RS3, general study area)**	**Comments**
Argiope argentata Orbweaver spider	WP1, WP3	
Ariadna solitaria Tunnel-web spider	WP1	
Articacia gemmatalis (moth)	WP3	
Asiomorpha coarctata Millipede	WP1, WP3	
Chiomara (asychis) vincenta White-patterned skipper	WP1, WP3	Local endemic
Cicada	WP1	
Cratomorphus insperata Firefly	WP1, WP3	
Dermaptera Earwig	WP1	
Diapherodes gigantea Guava lobster (walking stick)	WP3	
Diaprebes sp. Fly my lady (weevil)	WP1, WP3	
Dryas iulia framptoni Flambeau (butterfly)	WP1, WP3	Local endemic subspecies
Dysdercus discolor Cotton stainer bug	WP1, WP3	
Edsessa meditabunda Stink bug	WP1, WP3	
Enicospilus cubensis Wasp	WP1, WP3	
Hylephila phyleus Skipper	WP3	
Ischnothele caudata Funnelweb spider	WP3	
Ischnura ramburii Rambur's forktail (damselfly)	WP3	
Junonia genoveva Buckeye (butterfly)	WP3	
Leucauge regnyi Orchard spider	WP1, WP3	
Leucauge argyra Orchard spider	WP1, WP3	

Species (*Scientific name*, common name)	**Location Where Observed (WP1, WP3, RS1, RS3, general study area)**	**Comments**
Mastophyllum scabricole (grasshopper)	WP1, WP3	
Megalobulimus oblongus Giant South American snail		
Melampus coffeus Coffee melampus (snail)	WP1, WP3	
Menemerus bivittatus Jumping spider	WP1, WP3	
Microcentrum incarnates (grasshopper)	WP3	
Neococephalus sp. – green form (grasshopper)	WP1, WP3	
Neococephalus sp. – green form (grasshopper)	WP1, WP3	
Neotermes sp. Termite	WP1, WP3	
Nylanderia pubens Caribbean crazy ant	WP1, WP3	
Phoebis sennae Sulphur (butterfly)	WP1, WP3	
Phoebis agarithe Orange (butterfly)	WP3	
Physocyclus globosus Daddy-long-legs spider	WP1, WP3	
Phrymus tessellatus Whipscorpion	WP1, WP3	
Pleurodonte perpelexa Circular tree snail	WP1	
Polistes lanio Jack Spaniard wasp	WP1, WP3	
Polites dictynna Lesser whirlabout skipper	WP3	Regional endemic
Polygonus leo Skipper	WP3	
Polygonus manueli Skipper	WP3	
Porcellionides pruinosus Isopod	WP1, WP3	
Pseudolycaena cybele St. Vincent hairstreak	WP3	Local endemic
Pyrgus orcus Chequered	WP1, WP3	

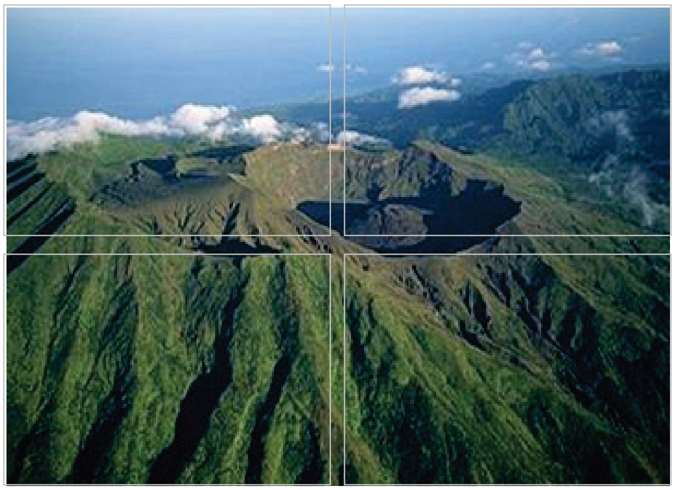
Species (*Scientific name*, common name)	**Location Where Observed (WP1, WP3, RS1, RS3, general study area)**	**Comments**
skipper		
Roach of tree-bark	WP1, WP3	
Roach of grass and leaf litter	WP1, WP3	
Rhinocricidae Millipede	WP3	
Schistocerca nitens caribbeana (grasshopper)	WP1, WP3	
Semiothisa everiata (moth)	WP3	
Stictia caementarium (wasp)	WP3	
Subulina octona Miniature awlsnail		
Streptostele musaecola (snail)	WP1, WP3	
Synchlora sp. (wasp)	WP3	
Urbanus obscurus Long-tailed skipper	WP1, WP3	
Utetheisa ornatrix (wasp)	WP3	
Unidentified grasshopper sp	WP3	
Tityus pictus Scorpion	WP3	Local endemic
Unidentified grasshopper sp	WP3	
Unidentified stink bug Flat, green	WP1, WP3	
Larbell firefly	WP1, WP3	
Unidentified weevil Fly my lady	WP1, WP3	
Small red ant	WP1, WP3	
Big black ant	WP1, WP3	
Biting ant	WP1, WP3	
Taktak	WP1, WP3	
Flies	WP1, WP3	
Mosquitoes	WP1, WP3	
Aquatic Molluscs		
Macrobrachium carcinus	River lobster	
Macrobrachium crenulatum	Gundy man	
Macrobachium faustinum	Crayfish	
Macrobachium heterchirus	Crayfish	
Atya innocous	Booky man	

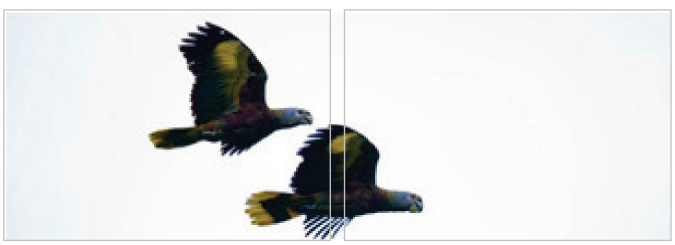
Species (*Scientific name*, common name)	**Location Where Observed (WP1, WP3, RS1, RS3, general study area)**	**Comments**
Fishes		
Sycidium plumieri	Sirajo goby	IUCN Data Deficient
Gobiesox sp.	Suck stone	

1.0 APPENDIX D: CULTURAL HERITAGE

Cultural Heritage Resources on the SVG National Register of Archaeological Sites and National Register of Historic Buildings

Resource Name
Layou Petroglyph
Black Point Tunnel
Fort Charlotte Peninsula
Fort Murray, Union Island
Balliceaux
Fitzhughes Heritage Center
Youroumei Heritage Village
Peter's Hope Estate
The Casson House
Cobblestone Inn
Montague House
Bishop's Court
Gonsalves Building
Police Headquarters
Botanic Gardens
HM Prison, Kingstown
Court House, Kingstown
Carnegie Building
Blue Caribbean Building
Government House
Jacob's Galleried House
Frangipani Hotel, Bequia
Lime Kiln, Bequia
Spring Estate, Bequia
Cotton House, Mustique





Prepared For:

St. Vincent Geothermal Project Phase I Exploratory Drilling Environmental and Social Management Plans

Draft Report

April 2016

Environmental Resources Management
1776 I (Eye) St NW
Suite 200
Washington, DC 20002

www.erm.com

ERM

Page intentionally left blank.

TABLE OF CONTENTS

This page intentionally left blank.

APPENDIX E
ENVIRONMENTAL AND SOCIAL MANAGEMENT PLANS

1 DRILL MUD AND CUTTINGS MANAGEMENT

1.1 INTRODUCTION AND OBJECTIVES

The Drill Mud and Cuttings Management Plan is designed to establish a framework for the proper handling of drill cuttings and drill muds generated during Phase I of the Project. This Plan includes strategies that will guide SVGCL and their drilling contractor to manage, mitigate, and avoid adverse effects to environmental and social receptors located within the Project AoI during Phase I. The objectives of this Plan are:

- Provide appropriate storage, handling, testing, transport and reuse of drilling mud or cutting onsite or disposal;
- List of measures necessary to mitigate any impacts on water resources (surface and groundwater) and aquatic habitat and species resulting from managing Drill Mud and Cuttings;
- Identify responsibilities and equipment required to deal with drill mud and cuttings used during Phase I; and
- Establish indicators to support management and encourage ongoing improvement regarding the handling of drill mud and cuttings on site.

1.1.1 *Key Impacts*

Drilling and injection works have the potential to affect water resources quality if geothermal liquid, wash water, mud and drill cuttings (collectively referred to as process wastewater) are not managed properly. The potential impacts associated with managing drill mud and cuttings are listed below:

- Modification to the physicochemical quality of the soil;
- Alteration in the physicochemical quality of surface waterbodies (rivers);
- Alteration of the structure of aquatic communities; and
- Alteration of the quality of groundwater.

1.1.2 *National/international Standards*

SVGCL has limited specific legal requirements for managing drill mud and cuttings. In this case, international guidelines should be applied and include:

- Emergency Response Plan (WI-070) prepared by RG;
- Contractor HSE Requirements prepared by RG (WI-030);

- Draft Environmental Management Act (2009);
- Waste Management Act (No. 31 of 2000) and Solid Waste Regulations (No. 11 of 2005);
- Environmental, Health, and Safety (EHS) Guidelines: Construction and Decommissioning, International Finance Corporation (IFC);
- Environmental, Health, and Safety (EHS) Guidelines: Geothermal Power Generation, International Finance Corporation (IFC);
- Environmental, Health, and Safety (EHS) Guidelines: Hazardous Materials Management;
- Environmental, Health, and Safety (EHS) Guidelines: Community Health and Safety - 3.7 Emergency Preparedness and Response; and
- Environmental, Health, and Safety (EHS) Guidelines: Hazardous Materials Management.

1.1.3 Mitigation Measures

Table 1-1 presents the framework for the Drill Mud and Cuttings Plan. This table also details minimum requirements for mitigation measures that will be implemented during Phase I to avoid, or control potential impacts on environmental or social receptors within the Project AoI. Disposal of cuttings, drill mud and additives will be completed in accordance with local/international laws and regulations in cooperation with authorities. The SVGCL will ensure that proposed mitigation measures are consistently meeting project standards. This will be achieved through periodic Plan reviews and the results of the monitoring programs.

Table 1-1: Drill Mud and Cuttings Management Measures

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
Soil and Water	Soil and Water contamination	Project's staff will receive appropriate required training related to manage drill mud and cuttings onsite and offsite; Construct an impervious lined mud pond to collect drill cuttings and recycle drill muds to minimize project water demand; Use non-toxic water-based drill fluids in accordance with the American Petroleum Institute (API) Rp 13B-1 practice (*Recommended Practice for Field Testing Water-based Drilling Fluids*); Dispose cuttings in accordance with national regulations. Water-based cuttings typically can be reused for construction fill if testing shows they are not toxic. Disposal of water-based drilling fluids into the bore hole following toxicity assessment; Include cuttings description in the Daily Geological Reports (DGR)	SVGCL General Manager/ EHS Manager Drilling Contractor,	Throughout construction	Daily site inspection and Audit reports Daily Drilling Report (DDR) and Daily Geology Reports (DGR) Monthly surface water quality monitoring upstream and downstream of the Project sites – no deterioration in pre-project river water quality

[a] http://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf

1.2 NOISE

1.2.1 Introduction and Objectives

The Noise Management Plan is designed to control and minimize potential sources of noise during Phase I of the Project. This Plan describes proposed measures and best management procedures (BMPs) to be implemented to protect environmental and social receptors from potential adverse impacts associated with the increase of airborne noise. The generation of noise levels is expected with any Geothermal project construction, but the implementation of the BMPs within this management plan will help control and minimize the noise disturbance.

This management plan defines the potential sources of noise, and establishes how they would be managed and monitored throughout the duration of Phase I of the Project. This Plan also provides guidelines that will help the SVGCL, its contractors and the environmental authorities of SVGCL determine the effectiveness of proposed mitigations.

The general objective of this Plan is to define framework and actions to implement the proposed mitigation to control and minimize potential sources of noise. The following objectives are also part of this Management Plan:

- Comply with applicable local and international noise requirements;
- Identify the potential sources of noise impacts during Phase I;
- Define construction and operation procedures for noise management;
- Align with international best practices;
- Define the procedures and mitigation measures to be applied to construction and operation activities associated with Phase I that have the potential to produce noise;
- Define training and communication commitments; and
- Define the monitoring, reporting, and adaptive management procedures for the Plan.

1.2.2 Key Impacts

The construction and operation activities associated with Phase I could result in the following negative impacts to Human settlements:

- Potential increase in daytime and nighttime airborne noise levels during Project exploratory drilling; and

- Potential increase in daytime and nighttime airborne levels during Project steam blow testing.

Drilling operations will be carried out 24 hours per day for two to six months. According to the *IFC EHS Guidelines for Geothermal Power Generation dated April 2007, Annex A*, drilling typically occurs throughout the life of a geothermal project, as production and injection wells need to be periodically updated to support power generation requirements.[i] Steam blow testing will occur for one to three months after drilling of the exploratory drill pads during the fourth stage of construction (i.e., exploratory blow testing).

1.2.3 National/International standards

There are no national noise standards in SVGCL[ii]; therefore, international limits for ambient/airborne noise levels should be applied. Legal and numeric standards applicable to the Project include:

- Occupational Risk and Controls Plan (WP-050) prepared by RG;
- Environmental, Health, and Safety (EHS) Guidelines: Construction and Decommissioning, International Finance Corporation (IFC);
- Environmental, Health, and Safety (EHS) Guidelines: Geothermal Power Generation, International Finance Corporation (IFC); and
- International Finance Corporation (IFC) limits for ambient/airborne noise levels .

In environments where the ambient noise levels already exceed a level of 55 dBA daytime and/or 45 dBA nighttime, the IFC indicates that additional noise emissions should not cause the ambient noise level in a residential area to rise by more than 3dBA. However, this criteria is relevant to long-term noise sources and they represent very stringent assessment criteria for temporary activities such as construction and seismic survey work. The IFC guidance summarized in Chapter 5- *Noise Impact Assessment* has been reviewed to establish a suitable set of criteria for the proposed Project. The duration of construction noise is accounted for by applying variable noise thresholds for significant impact.

1.2.4 Mitigation Measures

Table 2-1 presents the framework for noise levels management and implemented during construction and operation activities associated with Phase I of the Project. This table also details minimum requirements for mitigation measures that will be implemented during Phase I to avoid, or mitigate impacts

---

i This project phase (Phase I, Exploratory Drilling) does not include power generation. Phase II of the project, which is outside of the current scope, would include power generation.

[ii] SVGCL Noise Control Act of 1988 does not include numerical noise limits that applies to the proposed project; the Act mainly discuses noise abatement and prohibition of nuisance (e.g., operation of loud speakers and musical instruments), and penalties for violators of the Act.

on human receptors due to increases in airborne noise levels during daytime and nighttime exploratory activities. The SVGCL will review and approve contractor ESMPs prior to implementation.

The SVGCL will ensure that proposed mitigation measures comply with the projects standards described above. This will be achieved through periodic plan reviews, the results of site audits, and monitoring programs. Adaptive airborne noise management will be initiated when a guideline/standard described above is not met between the Project and the performance indicator.

The SVGCL EHS Manager will be responsible for keeping records of corrective actions and for overseeing the modification of environmental or social protection procedures and/or training programs to avoid repeating non-conformances and non-compliances.

Table 2-1: Noise Management Measures

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
Human Use and Residences	Potential increase in daytime and nighttime airborne noise during Project exploratory drilling; Potential increase in daytime and nighttime airborne noise during Project steam blow testing	Relocate noise receptors within W1 and W3 Reinjection well pad boundaries or provide temporary housing elsewhere for the entire duration of exploratory activities; Project's staff will receive appropriate required PPE and training in their use; Install safety signs where noise levels are above 85 dBA to prevent exposure of staff without appropriate required PPE (hearing protection); Install acoustic barriers/screens or use site objects or topography to block direct line of site between high noise level generating activities and potentially impacted noise receptors. Barriers should be located as close as possible to the source or to the receptor location to be effective;	SVGCL General Manager/ EHS Manager Drilling Contractor	Throughout construction	Daily site inspection and audit reports; Monthly (or on complaint) noise monitoring at the closest human receptors; Grievance Mechanism

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
		Select equipment with lower sound power levels that those assumed for the noise analysis in this ESIA. All engine exhausts and compressor components will be maintained regularly. Equipment that meets industry good practice will be selected; Maintain noise suppression devices (e.g. rock muffler) on construction vehicles and equipment. Keep the public informed about Project activities and efforts to minimize noise, and establish procedures for prompt response and corrective action with regard to noise complaints (i.e., grievance mechanism)			

1.3 SOIL EROSION AND SEDIMENT CONTROL MANAGEMENT PLAN

1.3.1 Introduction and objectives

The Soil Erosion and Sediment Control Management Plan is designed to ensure the reduction of potential impacts on soils and protect water resources within the Project AoI. The Plan includes methods that will guide the SVGCL and the Drilling Contractor to manage, mitigate, and avoid adverse effects on soils. The general objective of this Plan include:

- Comply with applicable local and international requirements;
- Prevent soils erosion and contamination;
- Align with international best practices;
- Define the procedures and mitigation measures to be applied to construction and operation activities associated with Phase I that have the potential to impact soils;
- Define management procedures for all soils-related functions including roles and responsibilities; and
- Define the monitoring, reporting, and adaptive management procedures for the Plan.

1.3.2 Key Impacts

The construction and operation activities associated with Phase I could result in the following negative impacts to soils:

- Soil erosion/landslides due to clearing and grading works for exploratory drill and injection pads, lying water pipeline, and deposition of excavated material; and
- Soil contamination due to accidental spills/releases or geothermal fluids during site preparation, drill rig installation and drilling and exploratory blow testing; and

1.3.3 National/International standards

SVGCL has limited specific legal requirements for soils managing. In this case, international soil guidelines should be applied and include:

- Waste Management Act (No. 31 of 2000) and Solid Waste Regulations (No. 11 of 2005);
- Forest Resource Conservation Act (No.47, 1992)
- Environmental, Health, and Safety (EHS) Guidelines: Construction and Decommissioning, International Finance Corporation (IFC); and

- Environmental, Health, and Safety (EHS) Guidelines: Geothermal Power Generation, International Finance Corporation (IFC).

1.3.4 Mitigation Measures

Table 3-1 presents the framework for soil and erosion control, which is to be elaborated in the final Project engineering design drawings, and implemented during construction and operation activities associated with Phase I of the Project. This table also details minimum requirements for mitigation measures that will be implemented during Phase I to avoid, or mitigate impacts on soils as a result of the Project.

The SVGCL will ensure that proposed mitigation measures are consistently meeting project standards. This will be achieved through periodic Plan reviews and the results of the monitoring programs. Adaptive soils management will be initiated when a guideline/standard described above is not met between the Project and the performance indicator.

Table 3-1: Soil Erosion and Sediment Control Management Measures

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
Soils	Soil erosion and landslides	Develop and implement soil erosion/sediment control plans, including control measures such as the use of silt fences, installation of temporary and permanent drainage systems to manage water runoff from the construction areas, and use of sediment basins; Use appropriate best management practices during clearance activities (to the extent practicable, schedule construction activities during the dry season, especially on steeply sloped areas; limit clearing and disturbance to the approved work zone area only; minimize the area of bare soil at any one time within the approved work zone as much as possible; and progressively stabilize and revegetate disturbed areas); Revegetate disturbed soils with fast-growing species that are common in the Project area including *Gliricida sepium*, *Chrysopogon zizanioides*, and bamboo (multiple species can be used);	SVGCL General Manager/ EHS Manager Drilling Contractor	Throughout construction	Daily site inspection and audit reports

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
		Improve feeder roads with adequate drainage ways; Reuse excavated material for slope stabilization of the drilling and injection pads.			
	Soil contamination	Develop and Implement a Spill Prevention Control and Countermeasures (SPCC) Plan to minimize the risk of spills and to ensure an appropriate response in the event of a spill. Reinject geothermal fluids into injection wells; Provide appropriate facilities/containers for segregation and temporary storage of general wastes on site; Establish site-specific processes for material, handling (receipt, unloading), storage, transportation and disposal (including recycling/reuse options).	SVGCL General Manager/ EHS Manager Drilling Contractor EHS Manager	Throughout construction	Daily site inspection and audit reports

1.4 WATER RESOURCES

1.4.1 Introduction and Objectives

The Water Resources Management Plan is designed to ensure the protection of water resources within the Project AoI. The Plan includes methods that will guide the SVGCL and the Drilling Contractor to manage, mitigate, and avoid adverse effects on water resources during Phase I. The general objectives of this Plan include:

- Protect surface and groundwater quantity and quality for local users and the environment :
- Define management procedures for all water-related functions including roles and responsibilities and training requirements;
- Comply with applicable SVGCL's regulatory requirements and recommended international guidelines (i.e., WHO, IFC, NOAA);
- Align with international best practices;
- Define and implement monitoring and reporting procedures; and
- Define responsible parties for the implementation of the management plan.

1.4.2 Key Impacts

The construction and operation activities associated with Phase I could result in the following negative impacts to water resources:

- Potential over-extraction of Rabacca River during exploratory drilling activities;
- Changes to downstream surface runoff patterns during site preparation including earthwork, clearing and grubbing activities;
- Potential degradation of surface and groundwater quality due to accidental spills/releases or geothermal fluids during site preparation, drill rig installation and drilling and exploratory blow testing;

1.4.3 National/International Standards

Legal and numeric standards applicable to the Project include:

- Central Water and Sewage Authority (CWSA) Act;
- Waste Management Act (No. 31 of 2000) and Solid Waste Regulations (No. 11 of 2005);
- Drinking water guidelines established by World Health Organization (WHO);

- Environmental, Health, and Safety (EHS) Guidelines: Wastewater and Ambient Water Quality, International Finance Corporation (IFC);
- Environmental, Health, and Safety (EHS) Guidelines: Geothermal Power Generation, International Finance Corporation (IFC);
- World Bank Group EHS General Guidelines on Community Health and Safety/Geothermal sector specific guidelines;
- Sediment, water quality and Aquatic Ecology: Screening Quick References Tables (SQuiRTs) guidelines prepared by NOAA (2008); and
- Rabacca River Ecological Flow: sufficient flow data are not available to quantify this flow, but ERM recommends that 50 percent of dry season flow be maintained as a general guidance, with monitoring of river providing input to adaptively manage this standard.

1.4.4 Mitigation Measures

Table 4-1 presents the framework for water resources management, which is to be implemented during construction and operation activities associated with Phase I of the Project. This table also details minimum requirements for mitigation measures that will be implemented during Phase I to avoid, or mitigate impacts on water resources as a result of the Project.

The SVGCL will ensure that proposed mitigation measures are consistently meeting project standards. This will be achieved through periodic Plan reviews and the results of the monitoring programs described in Section 6.4, *Monitoring Plan*.

Adaptive management for water resources will be initiated under the following conditions:

- When performance objectives are not being met at monitoring points for surface water, groundwater, and/or sediments; and
- When monitored surface water, groundwater, and/or sediment quality exceeds permissible levels, or may exceed permissible levels if the detected trends present this as a future possibility.

Additional surface and/or groundwater monitoring sites could be installed up-gradient of the receptor of concern.

The SVGCL EHS manager will be responsible for keeping records of corrective actions and for overseeing the modification of environmental or social protection procedures and/or training programs to avoid repeating non-conformances and non-compliances.

Table 4-1: Water Resources Management Measures

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
Rabacca River	Water extraction	Choose extraction flow rate and timing to minimize impacts on water course and to ensure minimum stream flow is maintained; Use ponds to store water for drilling; Recycle muds, apply closed systems for drilling activity/use of geothermal fluid (if applicable) or treated water from ponds to minimize need for new water. Trucking water in or store water in tanks and ponds during dry season;	SVGCL General Manager/ EHS Manager Drilling Contractor CWSA to authorize and audit water extractions from Rabacca River	Prior to extraction and throughout construction; Monitoring throughout construction;	Record quantity of water abstracted and timing of abstraction River flow monitoring No complaints from downstream users
	Water Quality	Preventive maintenance programs for equipment and vehicles (according to manufacturer requirements); Properly store and use of fuel and hazard materials; Avoid discharge of untreated wastewater into rivers/streams; Reuse of drilling fluid (where feasible); Control soil erosion in construction areas (hay bales and silt fences); Wastewater injection (geothermal fluids); Use of water-based drilling muds; Recycling of drilling muds; Lining with HDPE storage ponds and regularly check for rips and tears; Monitor and periodically remove accumulated silt from any sediment control	SVGCL General Manager/ EHS Manager Drilling Contractor	Mitigation throughout construction;	Monthly water quality monitoring – no deterioration in pre-project river water quality No complaints from downstream users

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
		ponds; Construct diversion drains and bunds to divert clean runoff away from construction areas and prevent contaminated water entering local water sources.			
Groundwater	Water quality	Lining, casing and grouting the drilling wells; Use water-based drilling fluids; Groundwater quality monitoring; Lining drilling water ponds Reinjection of water to avoid discharge of well brines to surfacewater Route effluent fluids to settling ponds; Create bunded areas in low lying land around injection pads and provide diversion channels around these bunded areas; Provide baseline of current springs to ensure any potential new springs created by excavation can be identified.	SVGCL General Manager/ EHS Manager Drilling Contractor	Mitigation throughout construction; Monitoring after exploratory wells blow out/overflow events; Daily inspections by SVGCL of Contractor (Only observations of non-compliance will be reported). At least two formal audits of Contractor by the SVGCL during contract scope.	Collection of groundwater samples and analysis by accredited laboratory from Overland Borehole or other borehole; Where applicable, drinking water guidelines established by WHO[c] should be used as KPI. No spills affecting groundwater quality; SVGCL will audit Contractor storage areas against mitigation requirements (i.e., availability of spill kits and adequate bunded storage for chemicals and fuels)' Site visit to identify location of springs and their flow rate by using a simple weir or bucket measurement

[a] http://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf

1.5 SPILL PREVENTION CONTROL AND COUNTERMEASURES PLAN

1.5.1 Introduction and Objectives

The Spill Prevention Control and Countermeasures Plan (SPCC) is designed to establish a framework for the proper handling of fuels, lubricants, and similar types of substances (chemicals) used during construction and operation activities associated with Phase I of the Project. The SPCC Plan includes strategies that will guide the SVGCL and the Drilling Contractor to manage, mitigate, and avoid adverse effects to environmental and social receptors within the Project AoI during Phase I. Finally, the SPCC Plan includes performance indicators aimed at measuring the effectiveness of the Project's environmental management and at encouraging constant improvements throughout Phase I. This Plan also includes the following objectives:

- List of measures necessary to mitigate any impacts resulting from accidental spills;
- Identify mechanisms to prevent, address, and report a spill (i.e., appropriate storage, transfer and use of chemicals and fuel on site);
- Identify responsibilities and equipment required to deal with a spill; and
- Establish indicators to support management and encourage ongoing improvement regarding the handling of chemicals on site.

1.5.2 Key Impacts

Situations that could potentially cause impacts relating to the handling of hydrocarbons, fuels, or chemicals occur when there are accidental leaks or spills of these types of liquids. Typically, these situations result from human error, technical failures, worn equipment, defective maintenance, or improper construction.

The potential impacts associated with spills are:

- Modification to the physicochemical quality of the soil;
- Alteration in the physicochemical quality of surface waterbodies (rivers);
- Alteration of the structure of aquatic communities; and
- Alteration of the quality of groundwater.

1.5.3 National/International Standards

SVGCL has limited specific legal requirements for managing spills. In this case, international guidelines should be applied. Guidelines/standards applicable to the Project include:

- Emergency Response Plan (WI-070) prepared by RG;
- Contractor HSE Requirements prepared by RG (WI-030);
- Draft Environmental Management Act (2009);
- Waste Management Act (No. 31 of 2000) and Solid Waste Regulations (No. 11 of 2005);
- Environmental, Health, and Safety (EHS) Guidelines: Construction and Decommissioning, International Finance Corporation (IFC);
- Environmental, Health, and Safety (EHS) Guidelines: Geothermal Power Generation, International Finance Corporation (IFC);
- Environmental, Health, and Safety (EHS) Guidelines: Hazardous Materials Management;
- Environmental, Health, and Safety (EHS) Guidelines: Community Health and Safety. 3.7 Emergency Preparedness and Response;
- Environmental, Health, and Safety (EHS) Guidelines: Hazardous Materials Management;
- National Fire Prevention Association (NFPA); and
- Sediment and Aquatic Ecology: Screening Quick References Tables (SQuiRTs) guidelines prepared by NOAA (2008).

1.5.4 Mitigation Measures

Table 5-1 presents the framework for the SPCC Plan, which will be implemented during construction and operation activities associated with Phase I of the Project. This table also details minimum requirements for mitigation measures that will be implemented during Phase I to prevent, and/or control potential impacts on environmental or social receptor as a result of accidental spills. The SVGCL will ensure that proposed mitigation measures are consistently meeting project standards. This will be achieved through periodic Plan reviews and the results of the monitoring programs.

The SVGCL and the Drilling Contractor must maintain spill control equipment for all of the fuels and chemicals storage areas onsite. The following materials must be provided:

- Absorbent material (i.e., speedi-dry, pads, and booms);
- Shovel/broom; and
- Temporary disposal bags.

Spill control equipment should be stored in locations, which are accessible to all employees and located near fuels/chemicals storage locations. The Drilling Contractor should inspect the spill control equipment periodically to ensure that they in working order and spill abatement materials are replenished as needed.

A communication/emergency contact directory should be prepared. This directory should include a list with all necessary contact number that may be needed in emergencies.

Table 5-1: Spill Prevention and Control Management Measures

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
Soils and Water	Soil and Water contamination	<u>*Execute measures before event:*</u> Project's staff will receive appropriate required training related to spills (i.e., causes, risks, management methods and use of emergency kits); Chemical substances, fuels and hydrocarbons should be properly stored, transported and managed according to NFPA guidelines; Investigation, remediation and validation procedures will be developed and used to establish the site as 'clean' in the event of a spill; Construct appropriate spill containment facilities for all chemicals and fuel storage areas. Any potentially hazardous materials on site will be kept in a secure and bunded area. Bunds will be designed to enable containment of 110% of the largest container volume, or 25% of the total storage capacity (whichever is greater); Any storage facility must: • Have a written procedure that explains each of the steps to be followed in case of a spill or leak. • Have a spill kit based on the volume of chemicals stored. Spill kits may include oleophilic blankets and cloths; retardant foams; sand, and any other item that prevents a spill from spreading (i.e., shovel, absorbent	SVGCL General Manager/ EHS Manager Drilling Contractor Emergency Response Team (ERT)	Throughout construction	Daily site inspection and Audit reports Monthly water quality monitoring – no deterioration in pre-project river water quality Audit reports (SQuiRTs [a] guidelines for freshwater can be used as KPI)

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
		paper, plastic bags). • Have a specific Emergency Plan. Use water based drilling muds rather than oil based; Material Safety Data Sheets (MSDS) for all stored substances will be held at each storage site; Locate hazardous material stores away from surface waters. Hazardous wastes must be collected in designated containers including classification and labelling as hazardous waste. Hazardous waste storage areas must be lined and capable of containing any potential spills. Stormwater runoff will be diverted away from hazardous materials stores. *Execute measures during event:* Inform immediately to the Emergency Response Team (ERT); Control spill by using Spill kits. The appropriate PPE should be used during control and cleaning spill activities; If necessary, soil or wood-made barriers will be built to control the expansion of the spill; In case that a watercourse is contaminated, the following activities			

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
		should be conducted: • Build soil-made barriers to limit the spill. A sedimentation basin will be built adjacent to the spilled zone to capture all the spilled soil and mud; • The spill course will be redirected to stop its contact with waterbodies; • Inform communities located downstream of the waterbody about the occurrence of the spill *Execute measures after event:* All the spilled liquids or solids will be properly removed and disposed; Investigations should be conducted to determine root-causes of the spill including the magnitude of damages (health, environmental and property) to implement new prevention measures. Prepare a report describing all causes of the spill, and clean-up activities. Develop and maintain a report of contaminated soils. This report should list all known and suspected areas of land contamination at sites associated with the Project.			

[a] http://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf

1.6 DECOMMISSIONING AND RESTORATION MANAGEMENT PLAN

1.6.1 Introduction and Objectives

This Plan presents specific guidance on prevention and control of community health and safety impacts that may occur at the end of the Project (Phase I) if it is found not feasible. Decommissioning activities may be conducted in case the results obtained from testing indicate that the exploration wells and pads are not suitable for production in Phase II. The equipment and material used in the Project (Phase I) will need to be decommissioned according to this Management Plan.

This Plan will guide the SVGCL and the Drilling Contractor to manage, mitigate, and avoid adverse effects environmental and social receptors during Phase I due to decommissioning activities.

The general objective of this Plan is to ensure that risks for adverse environmental and social impacts due to decommissioning activities are minimized. This Plan also includes the following objectives:

- List of measures necessary to mitigate any impacts resulting from decommissioning activities;
- Comply with applicable corporative, national, and/or international recommended guidelines :
- Align with international best practices;
- Define and implement monitoring and reporting procedures; and
- Define responsible parties for the implementation of the management plan and training requirements.

1.6.2 Key Impacts

Potential environmental impacts associated with decommissioning activities are similar to construction activities but of shorter duration than those during operation and maintenance phase. The following decommissioning activities are required:

- Dismantle and remove all structures, materials, equipment;
- Fill mud ponds;
- Properly close the exploratory and injection wells;
- Remediate any soil or other contamination; and
- Stabilize and restore site with native landscaping.

After these decommissioning activities, the SVGCL will restore to approximate site’s original condition or to some standard that results in stable environmental conditions, including filling in any ponds or pits and level and revegetate the pad areas. The Drilling Contractor will clean up the drill sites and transport the drill rig and other equipment to Kingstown Port, and then send the equipment back to its country of origin.

Environmental and social impacts for decommissioning activities will be similar to those addressed for the construction activities of Phase I, and those impacts can be also controlled and minimized by implementing similar mitigation measures than those during construction activities. Some of the potential impacts on environmental and social receptors are:

- Modification to the physicochemical quality of the soil;
- Potential increase in daytime and nighttime airborne noise levels (similar to those during drilling activities);
- Air emissions from vehicles and generators; and dust from land clearing, structure removal, cement mixing and truck and equipment traffic;
- Vegetation loss, disturbance noise, wildlife disturbance and displacement;
- Traffic impacts to vulnerable groups;
- Alteration in the physicochemical quality of surface waterbodies (rivers);
- Alteration of the structure of aquatic and terrestrial communities; and
- Alteration of the quality of groundwater.

1.6.3 National/international Standards

All decommissioning activities will refer to applicable corporate, national and/or international regulation and procedures including:

- Draft Environmental Management Act (2009);
- Waste Management Act (No. 31 of 2000) and Solid Waste Regulations (No. 11 of 2005); Environmental Management Act (Draft, 2009)
- Environmental, Health, and Safety (EHS) Guidelines: Construction and Decommissioning, International Finance Corporation (IFC);
- Environmental, Health, and Safety (EHS) Guidelines: Geothermal Power Generation, International Finance Corporation (IFC);
- Environmental, Health, and Safety (EHS) Guidelines: Hazardous Materials Management;
- Environmental, Health, and Safety (EHS) Guidelines: Community Health and Safety. 3.7 Emergency Preparedness and Response;

1.6.4 Mitigation Measures

Table 6-1 presents the impact avoidance, minimization, and mitigation measures that are specific to decommissioning activities to be implemented during Phase I of the Project. The SVGCL will ensure that the control and mitigation measures are fully and successfully implemented through periodic Plan reviews and assessment of the results of the monitoring activities outlined in Table 6-1.

Table 6-1: Decomissioning Management Measures

Receptor	Decommissioning Activities	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
Human settlements Farmland Water Resources (surface and groundwater) Biodiversity	Remove all structures, materials, equipment Fill mud ponds. Properly close the observation and injection wells. Remediate any soil or other contamination. Stabilize and restore site with native landscaping.	Implement Best Management Practices listed in the construction ESMP's. Follow Environmental, Health, and Safety (EHS) Guidelines: Construction and Decommissioning, International Finance Corporation (IFC). Remove all the infrastructure (e.g., structures, materials, equipment) and either export from SVG or dispose of properly Fill all excavated areas and adequately level the disturbed areas and re-spread the original topsoil or provide a suitable media for plant growth. Collect and remove any contaminated soil and remediate any other contamination. Abandon wells in a stable and safe condition. The abandoned well should be plugged and filled according to SVG's regulations and/or by following USGS[a] guidelines to prevent fluid migration. The method should	SVGCL General Manager/ EHS Manager Drilling Contractor	Throughout decommissioning and for at least three months afterwards to confirm adequate revegetation	Daily site inspection and audit reports. Vegetation monitoring to document restoration. Survey and collection records to be prepared for all decommissioned areas. Waste tracking and reporting is required to provide data on all waste amounts from generation through to disposal.

Receptor	Decommissioning Activities	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
		be designed to ensure that aquifers are isolated and the long term risk of aquifer or surface contamination is minimized. The hole should be sealed to the ground surface with cement plugs and the surface casing should be cut and capped below plow depth. If no SVG law exists, the casing should be cut off at approximately 0.6 m below ground surface and filled with grout from the bottom to the casing cut-off; then the excavation should be filled with native material.			

- [a] Guidelines and Standard Procedures for Studies of Groundwater Quality: Selection and Installation of Wells, and Supporting Documentation. http://pubs.usgs.gov/wri/wri964233/pdf/wri964233.pdf

1.7 BIODIVERSITY MANAGEMENT PLAN

1.7.1 Introduction and Objectives

This Biodiversity Management Plan (Plan) establishes a framework for minimizing impacts of the Project on terrestrial and freshwater aquatic biodiversity to be applied during Phase I of the Project. This Plan defines the actions that will enable the SVGCL and the Drilling Contractor to avoid, minimize, and avoid adverse effects to biodiversity receptors within the Project AoI during the Project's Phase I activities.

The key objectives of this Plan are:

- Establish SVGCL's responsibilities towards avoiding, minimizing, and mitigating impacts on terrestrial and freshwater aquatic biodiversity in the Project AoI.
- Define and describe the embedded controls (and mitigation measures to be applied to the Phase 1 activities that relate to management of biodiversity impacts.
- Define the roles and responsibilities for implementing the Plan.
- Define the monitoring and Key Performance Indicators (KPIs) that will be used to assess the effectiveness and success of the Plan at managing biodiversity impacts.

1.7.2 Key Impacts

Direct and indirect impacts to biodiversity can occur during four of the five Phase 1 activities, as summarized below:

- access improvements and transportation, which may result in vegetation loss, noise, and vehicular mortality;
- drill site preparation, which will result in vegetation loss and disturbance, noise, wildlife disturbance and displacement, and will require water abstraction from the Rabacca River which may impact aquatic biota;
- drill rig installation and drilling, which will create noise and related wildlife disturbance and require water abstraction from the Rabacca River; and

- exploratory testing, which will create noise and related wildlife disturbance.

The most significant impacts of the Project on terrestrial biodiversity relate to direct mortality or injury of any rare or endemic species and indirect impacts on wildlife, particularly rare and endemic species, related to the noise that will be generated during the exploratory drilling and steam blow testing activities.

The primary species of concern with respect to direct mortality and injury include: 1) rare and endemic plants that occur on the pad sites that will be removed or subject to damage from ground disturbing activities and accumulation of dust; and 2) wildlife that are unable to flee from the activity sites during site preparation activities, particularly sessile species such as the St. Vincent whistling frog, which is listed as Endangered by IUCN, is a local endemic species, and occurs at Exploration Drill Pad W1. The primary species of concern with respect to noise impacts from the Project is the St. Vincent parrot since the species is known to inhabit the forested ridges on each side of the Project area and parrots regularly use the Project area as a movement corridor between nesting and foraging habitats.

The most significant impact on aquatic habitat will be the loss of habitat due to extraction of water from the Rabacca River and the loss of continuity between the remaining habitats, particularly at the onset of the wet season when the river is driest. By reducing the volume of water in the Rabacca River, the water withdrawal may reduce the amount of habitat available to aquatic organisms throughout the river, reduce the local populations of aquatic organisms within the river, and possibly interfere with the migratory life cycles of several aquatic species. Entrainment and/or impingement of resident and migratory aquatic biota are the most significant potential impact of the Project on aquatic biota. Larval organisms passing by the withdrawal on their downstream migrations may be taken into the pipeline either routed to the water storage pond or injected directly into the wells.

1.7.3 National/International Standards

National standards relevant to biodiversity protection and management that are established under St. Vincent and the Grenadines laws and regulations include the following:

- Environmental Management Act (Draft, 2009)
- Forest Resource Conservation Act (No.47, 1992)
- Natural Resources Act (1947);
- Plant Protection Act (No.16, 2005) and Regulations (No. 9, 1991)

- Wildlife Conservation Act (1991)
- Wildlife Protection Act (No.16, 1987) & later amendments (1988 and 1991)

SVGCL is a signatory to various international conventions related to biodiversity:

- *The Convention on Biological Diversity (CBD)*: Objectives of the CBD include conservation and sustainable use of biological diversity, access to and equitable distribution of the benefits of genetic resources, and appropriate transfer of technology.
- *The Convention on the International Trade in Endangered Species (CITES)*: CITES's goal is to safeguard against threats to the survival of listed species arising from international trade in specimens, parts, or products of those species.

In addition to the above international conventions, the International Finance Corporation's Performance Standard 6 (IFC PS6) requires that project sponsors avoid, minimize, and mitigate threats to biodiversity arising from their operations. IFC PS6 specifies that mitigation measures should be designed to achieve 'no net loss' of biodiversity and favor impact avoidance and prevention over reduction and compensation (offsetting). IFC PS6 also requires project developers to develop and implement a monitoring and evaluation program to document the project's progress at implementing the agreed-upon controls, restoration, and mitigation measures, and their effectiveness at mitigating for impacts.

1.7.4 Mitigation Measures

Table 7-1 presents the impact avoidance, minimization, and mitigation activities that are specific to biodiversity to be implemented during Phase I of the Project. The SVGCL will ensure that the activities are fully and successfully implemented through periodic Plan reviews and assessment of the results of the monitoring activities outlined in Table 7-1.

Table 7-1: Biodiversity Management Measures

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
All Biodiversity Receptors	Biodiversity loss and disturbance	Provide training to Project field staff on the biodiversity features of the Project area, particularly the rare and endemic species potentially present in the area, and the procedures defined in this Biodiversity Management Plan	SVGCL General Manager/ EHS Manager	During worker induction or prior to site preparation activities	Documentation of training provided to staff and provision of written training materials. KPI: Training received by 100% of site workers.
All Biodiversity Receptors	Biodiversity loss and disturbance	Employ an environmental/biodiversity construction monitor during site preparation activities to ensure proper implementation of the measures defined herein, identify potential unforeseen impacts to terrestrial or freshwater aquatic biodiversity, and to apply adaptive management where needed to minimize impacts on vegetation and wildlife, particularly rare species	SVGCL General Manager/ EHS Manager	During site preparation activities	Daily reports by monitor documenting the day's activities and findings. KPI: Not applicable
Terrestrial Vegetation and Rare and Endemic Species	Direct loss and disturbance of habitat and vegetation	Minimize the footprint of activities and related ground and vegetation disturbance Time road improvements and site preparation activities in the wet or transition seasons to the extent practicable or implement dust control procedures (e.g., watering) when needed to control dust	SVGCL General Manager/ EHS Manager Drilling Contractor	During road improvement and site preparation activities	Documentation of Project footprint through monitoring. KPI: Vegetation disturbance is limited to exploration and injection pad sites and road improvement locations.

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
Terrestrial Vegetation and Rare and Endemic Species	Degradation of vegetation	Time road improvements and site preparation activities in the wet or transition seasons to the extent practicable or implement dust control procedures (e.g., watering) when needed to control dust	SVGCL General Manager/ EHS Manager Drilling Contractor	During road improvement and site preparation activities	Dust monitoring in conjunction with air quality monitoring activities. Vegetation monitoring to document dust-related impacts. KPI: No vegetation degradation from dust accumulation as documented through monitoring.
Terrestrial Vegetation and Rare and Endemic Species	Direct loss of rare and endemic plant species	Salvage and translocate rare and endemic flora in cooperation with local experts and consistent with Government of St. Vincent and the Grenadines requirements (authorization should be obtained from the Forestry Department under the Ministry of Agriculture in close collaboration/consultation with the National Parks Authority)	SVGCL General Manager/ EHS Manager Biodiversity Monitor	During site preparation activities	Collection and translocation records to be prepared for all plant collections and translocations. KPI: Identification and successful translocation of rare and locally endemic plant species from the pad sites prior to site preparation activities.
Terrestrial Wildlife and Rare and Endemic Species	Direct loss or injury of wildlife species	Conduct pre-clearing surveys prior to site preparation activities to flush wildlife and remove sessile wildlife, particularly rare and endemic species, from the well pad sites	SVGCL General Manager/ EHS Manager Biodiversity Monitor	Prior to site preparation activities	Survey and collection records to be prepared for all pad sites. KPI: Pre-construction surveys completed on all of the pad sites prior to site preparation activities.

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
Terrestrial Wildlife and Rare and Endemic Species	Direct loss of rare and endemic wildlife species	Salvage and translocate rare and locally endemic wildlife (with focus on sessile species that cannot move away from site activities on their own) in cooperation with local experts and consistent with Government of St. Vincent and the Grenadines requirements (authorization should be obtained from the Forestry Department under the Ministry of Agriculture in close collaboration/consultation with the National Parks Authority)	SVGCL General Manager/ EHS Manager Biodiversity Monitor	During site preparation activities	Collection and translocation records to be prepared for all animal collections and translocations. KPI: Identification and successful translocation of rare and locally endemic wildlife species from the pad sites prior to site preparation activities.
Terrestrial Wildlife and Rare and Endemic Species	Traffic-related mortality	Implement the Traffic Management Plan including strict enforcement of speed limits and limit nighttime driving	SVGCL General Manager/ EHS Manager Drilling Contractor	Throughout Phase 1 activities	Maintain records of traffic-related wildlife interactions. KPI: No injury or mortality of wildlife due to Project-related traffic.
Terrestrial Wildlife and Rare and Endemic Species	Noise-related habitat degradation and wildlife disturbance	Implement the noise reduction procedures identified in the Noise Management Plan Initiate drilling and steam blow testing prior to onset of the St. Vincent parrot breeding season (January) to the maximum extent possible	SVGCL General Manager/ EHS Manager Drilling Contractor	Throughout Phase 1 activities but particularly during drilling and testing	Breeding census and monitoring of St. Vincent Parrot activity in and around the AoI, particularly during the nesting season KPI: No abandonment of breeding territories in and around the Project AoI by St. Vincent parrots
Terrestrial Wildlife and Rare and Endemic Species	Light-related habitat degradation and wildlife disturbance	Minimize the amount of lighting used at the pad sites and use directional (downward facing) lighting	SVGCL General Manager/ EHS Manager Drilling Contractor	Throughout Phase 1 activities	Not applicable

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
Terrestrial Wildlife and Rare and Endemic Species	Hunting and freshwater fishing by Project workers	Implement and enforce strict no hunting and freshwater fishing policy for Project workers Include education on illegal wildlife trade and protected species law in Project employee induction and related environmental training	SVGCL General Manager/ EHS Manager	Throughout Phase 1 activities	Document communication of no hunting and freshwater fishing policy, review of inspection and enforcement records, KPI: No hunting or freshwater fishing infractions by Project staff
Freshwater Aquatic Habitat and Species	Aquatic habitat loss and disruption	Minimize water withdrawals during low flow periods	SVGCL General Manager/ EHS Manager Drilling Contractor	During drilling and testing	Monitoring of water abstraction and river flows during low flow periods to ensure surface flow is maintained KPI: Minimum environmental flow (e-flow) is maintained in the Rabacca River
Freshwater Aquatic Habitat and Species	Entrainment or impingement of aquatic biota	Minimize the intake velocity for the water abstraction	SVGCL General Manager/ EHS Manager Drilling Contractor	During drilling and testing	Monitoring of water intake velocity KPI: Not applicable
Freshwater Aquatic Habitat and Species	Entrainment or impingement of aquatic biota	Install wedgewire screens to exclude larval aquatic organisms from the water intake	SVGCL General Manager/ EHS Manager Drilling Contractor	Prior to water abstraction	Confirmation that wedgewire screens have been installed and are functional KPI: Minimal entrainment or impingement of larval aquatic organisms

1.8 SOCIOECONOMIC, HEALTH AND CULTURAL MANAGMENT PLANS

1.8.1 Introduction and Objectives

This Plan summarizes methods that will guide the SVGCL and the Drilling Contractor to manage, mitigate, and avoid adverse effects on social receptors during Phase I; additional managing activities that have effects on social receptors are also described in other management plans, where they indirectly affect social receptors through other receptors.

The general objective of this Plan is to define a framework and actions to implement the proposed mitigations. The following objectives are also part of this Plan:

- Comply with applicable local and international requirements;
- Align with international best practices;
- Define mitigation measures to ensure the management of risks to social receptors;
- Define management procedures for social-related functions including roles and responsibilities; and
- Define the monitoring, reporting, and adaptive management procedures for the Plan.

1.8.2 Key Impacts

The key socioeconomic and community health impacts surrounding the Project are physical resettlement, economic displacement, and noise impacts for residents and farmers near to exploration drill pads and injection pads, and traffic impacts to vulnerable groups. These impacts are expected to have a residual moderate impact considering project controls and after implementation of further mitigation measures.

1.8.3 National/International Standards

- Land Acquisition Act (Chapter 241, 1947);
- Environmental Health Services Act (No.14, 1991);
- Public Health Act (No.9, 1977);
- Town and Country Planning Act (No.45, 1992) & later amendments ;
- Environmental, Health, and Safety (EHS) Guidelines: Construction and Decommissioning, International Finance Corporation (IFC);
- Environmental, Health, and Safety (EHS) Guidelines: Geothermal Power Generation, International Finance Corporation (IFC); and
- IFC Performance Standards, 2012, Performance Standard 1.

1.8.4 Mitigation Measures

Tables 8-1 and 8-2 provide a list of the actions and monitoring activities required to avoid or mitigate potential negative Project impacts to acceptable levels. Key Performance Indicators (KPIs) are provided where necessary. This Table summarizes the minimum requirements for mitigation measures during Phase I to avoid or mitigate impacts to social receptors as a result of the Project.

The SVGCL will ensure that proposed mitigation measures are consistently meeting project standards. This will be achieved through periodic Plan reviews and the results of the monitoring programs. Adaptive soils management will be initiated when a guideline/standard described above is not met between the Project and the performance indicator.

Table 8-1 Socioeconomic Management Measures

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
Residents and farmers near to exploration drill pads and injection pads	**Physical resettlement**	• Resettlement Action Plan (RAP) - revised to include secondary resettlement location for primary project affected person (PAP) • Community Grievance Mechanism	SVGCL – Environmental / Social Manager	All activity phases	• Disclose RAP, including cut-off dates, rates, and transparent methods for compensation • Disclose grievance mechanism • Ensure stakeholders' feedback on drafts of SEP, RAP, ESMP mitigation measures, are followed by implementation of amendments into these documents. • Summarized quarterly reports on consultations with and grievances received from stakeholders, including information on the incidents and events that resulted in grievances • Following resettlement, completion audit by independent auditor to assess Project efforts to restore the living standards of PAPs have been properly executed. Completion report will verify that all physical inputs committed in RAP have been delivered and all services provided.
	Economic displacement	• Resettlement Action Plan (RAP) - revised to include Livelihood Restoration Plan • Community Grievance Mechanism	SVGCL – Environmental / Social Manager	All Activity Phases	• See monitoring for RAP above • Conduct formal quarterly engagement with local farmers impacted by economic displacement to compare income levels before and after displacement and performance of livelihood restoration strategies

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
	Stress on local infrastructure (housing, businesses)	• Community Grievance Mechanism • Local Employment and Supplier Development Plan	SVGCL – Environmental / Social Manager and Community Liaison Officer	During drill rig installation and drilling; and exploratory blow testing phases	• Track local hiring and purchasing trends
Existing potential workforce in Project-affected communities	**Economic benefits**	• Include requirements to prioritize local employment, taking into account available skills. • Ensure Drilling Contractor adheres to the Local Employment and Supplier Development Plan	SVGCL and Drilling Contractor	During access improvements and transportation; drill rig installation and drilling phases	• Track local hiring and purchasing trends
Existing businesses in the towns	**Economic benefits**	• See Economic Benefits Mitigation Measure above	SVGCL and Drilling Contractor	During access improvements and transportation; drill rig installation and drilling phases	• Track local hiring and purchasing trends
Local and foreign tourists at Bamboo Ridge	**Recreational and Tourism**	• Ensure Traffic Management Plan includes continued daytime access to the Bamboo Ridge trailhead	Drilling Contractor	During access improvements and transportation; drill rig installation and drilling phases	• Track number of grievances received from stakeholders that are related to loss of recreational amenity and respond with further engagement and mitigation

Table 8-2: Community Health Management Measures

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
Residents and farmers near to exploration drill pads and injection pads	**Noise**	• Provide day farmers with noise protection if needed and/or consider relocation lands	SVGCL Community Liaison Officer and Drilling Contractor EHS Manager	During drill rig installation and drilling; and exploratory blow testing phases	• Track and evaluate monthly grievances related to noise
	Traffic	• Implement Traffic Management Plan and Journey Management Plan • Ensure that movement of 'outsize' or 'large/long' vehicles, or convoys, will be timed, where practicable, to avoid busy traffic periods and will be restricted to the agreed access routes and the construction corridor • Implementation of safe driving protocols	Drilling and Transport Contractors	During access improvements and transportation and decommission phases	• Track and evaluate monthly grievances related to traffic • Liaise monthly with local health officials (at Sandy Bay Clinic and Georgetown Hospital) and police stations (Sandy Bay and Georgetown) to track and evaluate any traffic-related injuries and health concerns as a result of Project traffic • Document consultation with community members on traffic and road safety
	Increase in crime, prostitution, and conflict as a result of influx	• Implement Community Grievance Mechanism • Security Management Plan (including security guards, fencing, roving police patrols of Orange Hill) • Code of Conduct for all Project employees and contracted staff including zero-tolerance policy for drug use, sale or purchase • Project will issue a policy statement regarding sexually transmitted infections (STIs) including HIV/AIDS, and this policy will be communicated internally to staff, and externally to Contractors. • Provide training to local communities on grievance	SVGCL – Environmental / Social Manager and Community Liaison Officer	Throughout Project	• Document number of consultations and trainings with local communities on grievance mechanism • Engage monthly with local NGOs, civil society leaders and/or church leadership on local perceptions related to influx • Track and evaluate monthly grievances related to crime, prostitution, and conflict • Liaise monthly with local health officials (at Sandy Bay Clinic and Georgetown Hospital) and police stations (Sandy Bay and Georgetown) to track and evaluate any increase in crime and/or

Receptor	Impact	Mitigation Measures	Responsibility	Timing	Monitoring and KPI
		mechanism use and workforce policies on interaction with community members			prostitution within the Project area • Document number of workers and contractors who have signed Code of Conduct and zero-tolerance policy (target of 100%)
Populations in the nearest settlements to the Project area	**Noise**	• See Noise Mitigation Measures above	Drilling Contractor and Community Liaison Officer	During drill rig installation and drilling; and exploratory blow testing phases	• See Noise Monitoring above
	Traffic	• See Traffic Mitigation Measures above	Drilling Contractor and Community Liaison Officer	Throughout Phase I	• See Traffic Monitoring above
	Increase in crime, prostitution, and conflict as a result of influx	• See Influx Mitigation Measures above	SVGCL – Environmental / Social Manager and Community Liaison Officer	Throughout Phase I	• See Influx Monitoring above
Populations residing and working along Windward Highway from Project area to Port	**Traffic**	• See Traffic Mitigation Measures above	Drilling Contractor and Community Liaison Officer	Throughout Phase I	• See Traffic Monitoring above • Track and evaluate monthly grievances related to traffic from this receptor community

1.9 CULTURAL HERITAGE MANAGEMENT PLAN

1.9.1 Introduction and Objectives

IFC Performance Standard 8 defines cultural heritage as: "(i) tangible forms of cultural heritage, such as tangible moveable or immovable objects, property, sites, structures, or groups of structures, having archaeological (prehistoric), paleontological, historical, cultural, artistic, and religious values; (ii) unique natural features or tangible objects that embody cultural values, such as sacred groves, rocks, lakes, and waterfalls; and (iii) certain instances of intangible forms of culture that are proposed to be used for commercial purposes, such as cultural knowledge, innovations, and practices of communities embodying traditional lifestyles."

This Cultural Heritage Management Plan (CHMP) defines a series of steps to minimize impacts to cultural heritage within the Project area. The plan provides oversight and assurance measures to meet the Project's cultural heritage commitments outlined in the Environmental and Social Impact Assessment (ESIA). The objectives of the CHMP are to:

- Summarize the key impacts to cultural heritage identified in the Project ESIA;
- Identify the national and international cultural heritage standards applicable to the Project;
- Summarize the cultural heritage mitigation measures identified in the Project ESIA; and
- Describe a Chance Finds Procedure to be followed in the event that cultural heritage is inadvertently discovered during construction activities.

The principles adopted with regard to cultural heritage impacts are to:

- Avoid the development or occurrence of an impact where possible;
- Minimize the scale and duration of unavoidable impacts; and
- Enhance positive outcomes.

1.9.2 Key Impacts

The cultural heritage impact assessment identified a number of potential direct and indirect Project impacts to known and undiscovered cultural heritage resources within or adjacent to Sites W1 and W3; feeder roads; and the Windward Highway. Potential impacts include:

- Indirect impacts to resources along the Windward Highway due to increased vehicular traffic and associated temporary, short term changes to resource setting/ambiance and restrictions to user access caused by the addition of Project vehicles to existing traffic;
- Direct impacts to resources along the Windward Highway due to increased vehicular traffic due to increased pollution and vibration from increased traffic flows and physical impacts from potential traffic accidents; and
- Direct impacts to known and undiscovered archaeological resources during construction of W1, W3, injection wells, and the widening of the W1 and W3 feeder roads.

The potential indirect and direct impacts to resources along the Windward Highway were determined to be negligible due to their relatively short duration and small magnitude. As a result, no additional actions are required to mitigate these potential impacts. However, the impact assessment determined that potential direct impacts to known and undiscovered archaeological sites, the Byera Tunnel, and the Orange Hill Aqueduct required mitigation.

Based on the results of the desktop study it was determined that four previously identified archaeological sites are likely located near the W1 and W3 feeder roads. These four resources could be impacted by ground disturbing activities associated with road widening. In addition, the presence of a number of known archaeological sites near Project development areas indicates there is significant potential for undiscovered archaeological resources within Project areas. Ground disturbing activities associated with Project construction could result in significant impacts to any undiscovered archaeological sites with the Project footprint.

The Byera Tunnel and Orange Hill Aqueduct are both located along the Windward Highway route from the Port of Kingstown. All Project traffic traveling to W1 and W3 will have to pass through the Byera Tunnel and all traffic traveling to W3 will have to pass through the aqueduct. Any accidental events such as traffic accidents, insufficient overhead clearance, or insufficient turning radius, could result in significant impacts to these resources.

1.9.3 National/International Standards

- Saint Vincent and the Grenadines National Trust Act (1969);
- SVGCL's Preservation of Historic Buildings and Antiquities Act (1976);
- IDB Technical Note 896: Managing the Impacts of IDB Projects on Cultural Heritage (2015); and
- IFC Performance Standard 8: Cultural Heritage (2012).

1.9.4 Mitigation Measures

Mitigation of impacts to tangible cultural heritage resources may take a variety of forms depending on the type of resource or the present knowledge or understanding of the resource. Avoidance of impacts is always the preferred mitigation measure, followed by reducing impacts through engineering or administrative controls, and lastly through resource removal, replacement, and/or data recovery. Table 9-1 provides a series of recommended mitigation measures to reduce or eliminate impacts to the four archaeological sites, undiscovered archaeological sites, the Byera Tunnel, and the Orange Hill Aqueduct.

Table 9-1: Cultural Heritage Management Measures

Receptor	Impact	Mitigation Measures	Responsibility	Monitoring and KPI
Archaeological Sites • Dandrade 2 • Orange Hill 1 • Orange Hill 2 • Lot 14 • Previously Unidentified Sites	Direct physical impacts/disturbance by construction of W1, W3, and injection wells and widening of W1 and W3 feeder roads	Avoidance	Drilling Contractor	• Chance Finds Procedure (see below). • Site Protection Program (see below). • Cultural Heritage Training Program (see below). • Submission of Chance Finds Procedure to SVGNT for review and approval. • Documentation of reporting and consultations with SVGNT if Chance Finds are encountered. • Reports generated from archaeological excavations, monitoring, or other mitigations (if necessary).
Byera Tunnel and Orange Hill Aqueduct	Direct physical impacts/damage due to traffic accidents during mobilization or demobilization of equipment to Project areas.	Reduced speed through tunnel and under aqueduct	SVGCL and Transport Contractor	• Traffic Study and Management Plan. • Monitoring compliance with Traffic Management Plan. • Monitoring trucks and drill rigs traveling through tunnel and aqueduct.

1.9.5 Chance Finds Procedure

This section outlines the proposed Chance Finds Procedure. Chance finds are defined as potential cultural heritage (or paleontological) objects, features, or sites that are identified outside of or after a formal site reconnaissance, normally as a result of construction monitoring. Chance finds may be made by anyone on the Project including archaeologists, architectural historians, non-cultural heritage site workers, and visitors or guests. Cultural heritage resources may be associated with prehistoric or historic periods and may include:

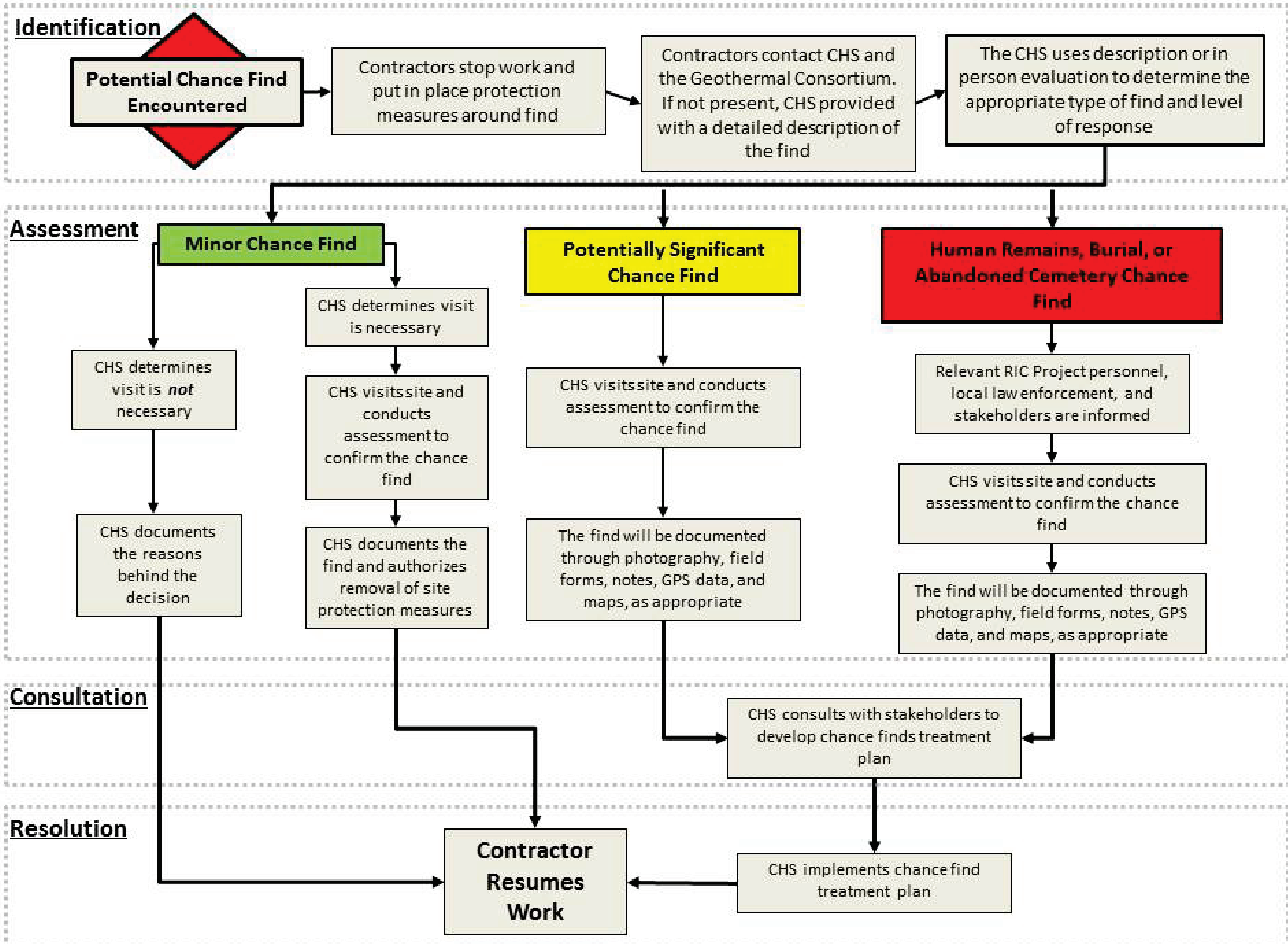
- Artifacts, whole or partial, such as ceramic sherds, ground and chipped stone artifacts, glass fragments, bone, shell, metal, textiles, and plant and animal remains;
- Features associated with human occupation, such as trash dumps, middens, hearths, and structural remains including temples, fortifications, habitations, walls, and monuments;
- Prehistoric or historic human remains found in formal graves, cemeteries, or as isolated occurrences;
- Underwater cultural heritage, including shipwrecks, dockyards, piers, wharves, ports, navigational markers, fishing weirs, breakwaters, human remains or burials, and inundated prehistoric or historic terrestrial archaeological site;
- Architecture, landscape, and other built heritage features; and
- Paleontological resources, including fossilized plant or animal remains or their impressions.

The Chance Finds Procedure will use a multi-tiered approach for identifying, assessing, and resolving potential chance finds. The purpose of this approach is to empower cultural heritage monitors in the field to resolve minor chance finds without necessitating consultations with national level authorities and minimize construction delays by allowing for the quick resolution of non-significant chance finds by a Cultural Heritage Specialist (CHS) in the field. The defining characteristics of each chance find tier and the processes for assessing and determining if consultation is required will be developed in consultation with cultural heritage stakeholders. A preliminary three-tiered chance finds hierarchy is presented in Table 9-2. All potential chance finds identified by Project personnel will be reported to a CHS, who will determine if it is a chance find and, if so, to assign it to a chance finds tier. Figure 9-1 provides a detailed description of the chance finds procedure.

Table 9-2: Three-tiered Chance Finds Hierarchy.

Receptor	Impact	Mitigation Measures
Minor Chance Finds	Modern objects or features. Isolated historic or prehistoric artifacts that are out of context or lack research potential or value.	Construction work stopped in the area of the find. If CHS not present, potential find reported to CHS. CHS will determine if find site visit is necessary. If CHS is present or determines site visit is necessary, find will be documented and collected/resolved in the field by CHS without stakeholder consultation. Construction activities resumed in the area.
Potentially Significant Chance Finds	Potentially significant prehistoric or historic artifacts, features, cultural heritage sites, or cultural heritage site clusters.	Construction work stopped in the area of the find. If CHS not present, potential find reported to CHS. CHS will visit find site and document find. If find is determined to represent a potentially significant chance find, CHS will initiate consultation with stakeholders to develop treatment plan. Construction works will resume in the area upon completion of treatment plan.
Human Remains, Burials, Abandoned Cemeteries Chance Finds	Prehistoric, historic, or modern human remains, burials, or associated artifacts or features.	Construction work stopped in the area of the find. If CHS not present, potential find reported to CHS. CHS will report find to stakeholders, including local, regional, or national law enforcement agencies. CHS will initiate consultation with stakeholders to develop treatment plan. Construction works will resume in the area upon completion of treatment plan.

Figure 9-1: Chance Finds Procedure Flow Chart.



Site treatment plans to be considered include preservation in place through avoidance or specialized construction techniques, and rescue excavations in advance of additional construction work if avoidance is not possible. Only after all treatment work is agreed and any required excavations carried out is project activity allowed to resume in the area.

Artifacts collected in connection with chance finds should be minimized. Those retained because they are accidentally unearthed or broken free of their soil matrix should be retained with precise notation of their original location, and with photographs taken of their original context. Artifact photos and site photos may be useful for consultation regarding chance finds and should be taken as soon as possible. Artifacts and associated notes and photographs taken by any Project personnel should be given to a CHS as soon as possible. Ultimately the artifacts belong to the SVGCL, and the CHS will be responsible for giving the artifacts to the government authorities (i.e., the Saint Vincent and the Grenadines National Trust, or SVGNT).

Project and the Drilling Contractor staff will be required to maintain records of monitoring, chance finds, and chance find response measures executed. These will include:

- Daily monitoring records indicating areas and activities monitored; reported chance finds and the results of any evaluations; and communications and instructions (such as stop work and resume work);
- Weekly reports summarizing reporting period activities including chance finds, assessments and evaluations, internal and external communications and instructions, and supporting photographic documentation (or other reference materials as appropriate). An additional report aimed at fulfilling any specific SVGNT requirements is also anticipated; and
- Monthly reports summarizing monitoring and evaluation results, status of any site treatment measures required, instructions to the SVGCL and the Drilling Contractor, and other internal and external communications. Additional monthly reporting may be required by SVGNT.

Cultural Heritage Training Program: Relevant Project personnel will receive training and demonstrate competency in: (1) the identification of chance find cultural heritage sites, objects, or features; and (2) chance find management procedures (i.e., actions that are required in the case of a suspected chance find). This training will be incorporated into the overall induction process for the SVGCL and the Drilling Contractor and will include a quick reference handout.

All employees must be aware that it is illegal and forbidden to disturb or remove cultural heritage objects offsite for personal gain. Disciplinary action will be taken against any personnel who violate this requirement. To support the training process, the SVGCL will develop training materials for use in the overall induction process.

Site Protection Program: Known cultural heritage sites will be protected from Project-related damage. This includes sites identified in advance of construction activities and those found during construction (chance finds). Sites may be located in Project areas or adjacent to them. Site protection measures may include warning signs, physical barricades, or other visual indicators of areas of high cultural heritage sensitivity. In some cases it may be necessary to modify construction techniques to protect sites in work areas, for example, building up the running track to protect cultural heritage features from vehicle traffic or the use of excavators with smooth edged buckets to minimize the potential for soil disturbance.

Site information will be provided to Project personnel in written and verbal form in official transmittals, meetings, and tool box talks as appropriate to ensure that known cultural heritage sites are protected.

1.10 TRANSPORTATION AND TRAFFIC MANAGEMENT PLAN

The key transportation issues surrounding the Project are transportation safety concerns associated with the movement of Project components and construction equipment from Kingstown Port to the Project site via Windward highway, as well as physical road infrastructure. Table 10-1provides a list of the actions and monitoring activities required to avoid or mitigate potential negative Project impacts to acceptable levels.

Table 10-1: Transportation and Traffic Management Measures

Receptor	Impact	Mitigation Measures	Responsibility	Monitoring and KPI
Pedestrians and Cyclists	Increased safety risk due to the presence of large Project-related vehicles.	Preparation of and adherence to a Journey Management Plan, including (but not limited to): • Use of escort vehicles; • Proper training and licensing of all Project drivers; and • Regular inspection and maintenance of Project vehicles.	SVGCL	Presence of a master trip schedule and a Journey Management Plan for every Project-related trip.
		Regular, scheduled communication with community stakeholders, to ensure maximum awareness of Project-related vehicle movements.	SVGCL – Environmental / Social Manager and Community Liaison Officer	Adherence to meeting schedule.
All road users	Degradation of road infrastructure	Preparation of and adherence to a Journey Management Plan, including (but not limited to) a requirement to transport tracked vehicles via trailer, rather than driving directly on public roads. Repair any damage to roads or other structures caused by the Project	SVGCL Transport Contractor	Presence of a master trip schedule and a Journey Management Plan

2 ENVIRONMENTAL AND SOCIAL MONITORING PLAN

This section provides a summary of the monitoring, control, and follow-up measures identified in the Environmental and Social Impact Assessment (ESIA) and in individual management plans. The general objective of this Monitoring Plan (MP) is to inspect/monitor and evaluate the efficiency of the impacts, embedded controls, and proposed mitigation measures that will be implemented during Project's lifecycle. This Monitoring Plan also identifies the responsible parties, roles, and procedures for implementing the various monitoring programs, including monitoring methodologies, monitoring frequency, and the location and number of the monitoring sites.

2.1 PROJECT STANDARDS

The Project-specific resource area monitoring standards, protocols, guidelines, laws, and legal requirements to be followed during the monitoring of Phase I are detailed in the individual management plans and are not discussed in this Plan. The Project Standards section in each of the management plans outlines the specific standards applicable to each resource-monitoring plan.

2.2 ROLES AND RESPONSIBILITIES

2.2.1 SVGCL

The SVGCL will be responsible for monitoring the overall effectiveness of the monitoring measures detailed in each resource management plan and this Plan and will have within its staff environmental and social managers and coordinators to oversee implementation of the monitoring programs.

Overall responsibility for Environmental, Health, and Safety (EHS) performance of the Project lies with the SVGCL corporate-level management. This Plan will be integrated and delivered through the SVGCL to ensure:

- Ownership of the Plan from the highest level of the company;
- Appropriate resource allocation for implementation of the Plan; and
- Efficient and effective execution of the Plan.

At the Project execution level, responsibility for implementation monitoring, control, and follow-up measures, including contractor EHS management, lies with the Project Environmental, Health, and Safety (EHS) team.

The Project EHS manager has the following responsibilities:

- Have overall responsibility for the implementation of this Plan.
- Provide guidance to project staff on appropriate protection of the environment.
- Employ environmental staff who will regularly monitor the SVGCL and the Drilling Contractor's performance;
- Work with the procurement departments to ensure that reputable contractors and supply firms are used;
- Recommend correction actions when necessary; and
- Review and update this Plan as required.

Specific responsibilities for delivering the Plan commitments related to contractor actions will be assigned as relevant to the Project EHS manager, Project staff, and contractors, but the Project overall EHS director will provide oversight and have ultimate responsibility.

2.2.2 Contractors

The SVGCL is responsible for Project execution. However, the majority of monitoring measures in the construction phase will be implemented by the Drilling Contractor.

The Drilling Contractor (contracted directly by the SVGCL) has the following responsibilities:

- Undertake this and other management plans designed for the construction and operation of the Project and ensure Project monitoring measures and standards are met.
- Develop their own monitoring plans and inspection procedures consistent with the requirements described in this Plan before starting work. These management plans and procedures should be reviewed and approved by the SVGCL for consistency.

All monitoring measures for which construction contractors will be responsible will be outlined in the service contracts between the SVGCL and the contracting companies. Each contractor company will appoint at least one staff member charged with overseeing the implementation of the mitigation measures, as well as monitoring their implementation and effectiveness where relevant.

Table 11-1: Project Monitoring Summary

Environmental and Social Components	Parameters	KPI	Location or Number of Monitoring Sites	Monitoring Frequency	Sampling Technique	Report Type and Frequency	Reporting Responsibilities	Submitted to
Air Quality	H2S	ACGIH Guidelines	At each site and the closest down gradient residence	Continuous (real-time)	Electrochemical sensor in a personal monitoring instrument	Monthly Environmental and Social Performance Report	SVGCL General Manager/ EHS Manager Drilling Contractor	SVGCL
Noise	Leq dBA	IFC standards	Closest noise sensitive receptors (e.g., residence), one location in nearby St. Vincent Parrot habitat, and Bamboo Range.	Initial one week monitoring when drilling is at full operation and when steam flow testing is at full operation.	Calibrated sound level	Monthly Environmental and Social Performance Report	SVGCL General Manager/ EHS Manager Drilling Contractor	SVGCL
Soil	Soil Erosion and Contamination	No visible evidence of sediment leaving the Project site Number and volume of spills	Within construction area	Daily site inspection and audit reports	Inspection	Monthly Environmental and Social Performance Report	SVGCL General Manager/ EHS Manager Drilling Contractor	SVGCL
Wastes (drill mud and cuttings)	Volume of wastes spilled or improperly managed	Volume of drill mud spilled	Waste tracking and reporting on all waste amounts	Daily site inspections Audit reports	Daily site inspection and audit reports	Monthly Environmental and Social Performance Report	SVGCL General Manager/ EHS Manager Drilling Contractor	SVGCL
Water Resources	Surfacewater quality - pH, turbidity, conductivity, TDS, TSS, the principal elements found in the geothermal fluids, sulfate, and coliforms	No deterioration in water quality from upstream to downstream locations SQuiRT[a] standards	One upstream and one downstream sampling site on Rabacca River; One upstream and one downstream sampling site at W3	Sample 2 months before starting construction activities. Monthly throughout construction.	Hand dipped sample	Monthly Environmental and Social Performance Report	SVGCL General Manager/ EHS Manager Drilling Contractor	SVGCL
	Surfacewater quantity (streamflow gauge at Rabacca River)	Maintain minimum environmental flow required by Government	Continuous or daily water level recorder at existing stream gauge on	Continuous or daily before and throughout construction	Water level recorder	Monthly Environmental and Social Performance Report	SVGCL General Manager/ EHS Manager Drilling Contractor	SVGCL

Environmental and Social Components	Parameters	KPI	Location or Number of Monitoring Sites	Monitoring Frequency	Sampling Technique	Report Type and Frequency	Reporting Responsibilities	Submitted to
		or 50% of dry season flow	Rabacca River					
	Groundwater quality	WHO drinking water guidelines	Closest downgradient well or borehole	Before construction to establish baseline and at decommissioning and in response to any groundwater related complaints	Monitoring wells	Monthly Environmental and Social Performance Report	SVGCL General Manager/ EHS Manager Drilling Contractor	SVGCL
Biodiversity	Terrestrial flora and fauna	100% Survival of translocated plants. Same for animals where feasible to monitor translocated individuals.	Translocation sites (to be determined based on species and habitat requirements)	Monthly for three months following translocation	Qualified biodiversity specialist	Monthly Environmental and Social Performance Report	SVGCL General Manager/ EHS Manager EPC contractors, drilling contractor	SVGCL Forestry Department Parks and Rivers Department
	St. Vincent Parrot	No nest abandonment	Forest surrounding the pad sites	Monthly during breeding season	Qualified biodiversity specialist	Monthly Environmental and Social Performance Report	SVGCL General Manager/ EHS Manager	SVGCL Forestry Department Parks and Rivers Department
	Aquatic flora and fauna	No entrainment of aquatic organisms	Water intake	Monthly during water extraction	Visual inspection	Monthly Environmental and Social Performance Report	SVGCL General Manager/ EHS Manager Drilling Contractor	SVGCL Parks and Rivers Department
	Physical resettlement	Number and type of grievances regarding physical resettlement	NA	Ongoing throughout resettlement process	Monthly meetings with physically resettled people	Monthly Environmental and Social Performance Report Annual summary report on the RAP progress Resettlement	SVGCL General Manager/ EHS Manager	SVGCL

Environmental and Social Components	Parameters	KPI	Location or Number of Monitoring Sites	Monitoring Frequency	Sampling Technique	Report Type and Frequency	Reporting Responsibilities	Submitted to
						completion report		
	Economic displacement	Income levels before and after displacement and performance of livelihood restoration strategies Number and type of grievances , regarding economic displacement	NA	Formal quarterly engagement with and survey of local farmers impacted by economic displacement	Meetings/ interviews with local farmers Submissions to the grievance mechanism	See monitoring for physical displacement above Quarterly report based on analysis of engagement with local farmers	SVGCL Environmental and Social Manager and Community Liaison Officer	SVGCL
Socioeconomic	Economic benefits	Number of local full time equivalent hires	NA	Monthly	Track in payroll	Monthly Environmental and Social Performance Report	SVGCL EHS Manager Drilling Contractor	SVGCL
	Recreational use at Bamboo Range	Number and type of grievances received from recreational users or guides	To be determined during stakeholder engagement process	Monthly	Grievance Reports and CLO coordination with Bamboo Ridge Guides	Monthly Environmental and Social Performance Report	SVGCL Environmental and Social Manager and Community Liaison Officer	SVGCL

NA= Not Applicable